DRS2016
Design + Research + Society
Future-Focused Thinking

2016 Design Research Society
50th Anniversary Conference
27-30 June 2016, Brighton, UK

Ad Hoc Pairings: Semantic Relationships and Mobile Devices

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Abstract: As the digital world continues to become more mobile and wireless, a new challenge has arisen in this always connected landscape. That challenge has been created by the very thing that has helped to enable this nomadic experience – the loss of wires has resulted in a loss of what was once visually mapped connections between two or more digital objects which helped to semantically defined the relationship between ad hoc devices as well as user and devices. Current applications require the use of screen-based (explicit) interfaces to manage these connections but this research explores opportunities to leverage more implicit and tangible methods to creating these connections. This research and resulting user study (N=12) explored the use of gestures between primitive forms as a means of encoding paired relationships. The analysis of the resulting 108 patterns generated helped to isolate pairing attributes and an encoding protocol that could inform current and future tangible connections between digital devices.

Keywords: industrial design; interaction design; mobile computing, ad hoc

1. Introduction

As many have predicted, digital objects and their future incarnations continue to weave themselves into the everyday world (Weiser, 1991). This growing computational world is not only filled with digital devices and their resulting interfaces but also the networks that connect them. Connectivity is as much about ubiquitous networks as it is about the objects that inhabit them. The particular increase in wireless networks have allowed for devices and their users to become free from the burden of wired connections. As a result, wireless networks have been implemented to address a range of issues that wired connections could not (Aarts & Marzano, 2003) as well as breaking down the barrier of managing various cord nomenclature or unique port connections between different device manufactures (Miller, 2001). In many ways the increase in wireless connections has been both a blessing and a curse. Wires for all their challenges and nomenclature issues also provided visually 'mapped' (Norman, 1988) connections that helped users to define the 'relationship' between two or more devices. Design's response to this problem has been to push the relationship management of connected wireless devices to explicit screen-based interfaces. As a conceptual model (Krippendorff, 2006) of connected relationship, this approach can be particularly troublesome when it comes to ad hoc devices that operate within an infrastructureless network. In this ad hoc future, users will have the ability to connect any number of ubiquitous devices in order to share data, control operations, or expand their personal relationships with other users just to name a few (Elixmann, 2003). These personal area networks (PAN) like Bluetooth and near-field aim to promote a decentralized approach to computing with a diverse set of connection possibilities (Hansmann, et al., 2003). Along with this decentralization has come a variety of use cases that will need to be addressed as they relate to the Internet of Things (IoT) (van Kranenburg, et al., 2011), the least of which is the relationship management and instrumental engagement (Greenfield, 2006) between many of these connected objects. Connecting, controlling, and coordinating escalating environments of devices will enable users to expand their personal relationship and share data as well as control everyday objects in new and exciting ways (Elixmann, 2003). To that end, screen-based interfaces will not be the only means to coordinate these interactions and design has the opportunity to utilize the physical object itself to guide these connections. This approach may come to contribute to a type of 'ubicomp grammar' or ubicomp user interface (UUI) (Quigley 2010) to better enable the integration of computation in to everyday objects and leverage their tangible qualities.

This research and resulting user study (N=12) explored the use of gestures and pattern making between primitive forms as a means of encoding paired relationships. The analysis of the resulting 108 patterns generated helped to isolate pairing attributes an encoding protocol that could inform current and future implicit tangible interfaces between digital devices.

2. Semantics and spatial organization

Creating connections and relationships between digital devices was once the domain of the plugs and the wires. As that continues to shift to more ubiquitous forms of wireless connection, design will need to develop a new semantic approach for what it means to be connected. At the end of the day, the goal for most designers and perhaps design as a discipline is to develop 'meaning'. In this context, the word 'meaning' is the ability to convey signs (Boradkar, 2010) of a given system through pattern and structure (Kazmierczak, 2003) so as to allow for the user to interact with that system in a productive way. Design has developed some of its own approaches to the systematic analysis and construction of meaning. In the particular practice of product design, the approach to semiotics is often referred to as 'product semantics' (Krippendorff & Butter, 1984) or the study of the symbolic qualities of artefacts and how these qualities inspire people to interact with them. This point of view is primarily grounded in the perceptual aspects (sense making) that an artefact may illicit through the design and construction of interface and form. This school of thought has led to a series of guiding principles or good practices when endeavouring to communicate the utility of an object as well as how to directly interact with that object. In the past, the naturalness of form (Krippendorff, 2006) in artificial objects was driven by the manufacturing process utilized to create the artefact as well as the inherent functionality (mechanical workings, etc.) of the object which could aid users in better communication and interaction. With the growing absence of these qualities informing computational devices, a certain level of functional ambiguity has arisen (Kawanari, 2011). In an effort to combat the loss of these qualities, design must attempt to encode a sense of operation, relationship, and status into machines so as to be decoded by users. Much of the discourse, practice, and theory surrounding product semantics as well as the application of its tenants (affordance, constraint, mapping, etc.) (Gibson, 1979) (Norman, 1988) have done little to directly prescribe for the dynamic and time based signals that digital products are capable of producing.

The goal of this research was to determine new tangible ways in which users can generate paired wireless relationships between two Bluetooth devices utilizing the formal attributes of the shape and its relationship to other shapes or objects. In an effort to gain knowledge and create a framework for future design, this study sought to understand and ultimately develop a protocol for encoding spatial relationships between two or more digital objects. This study is grounded in both psychological theory coupled with the resulting findings.

The challenge of understanding relationships based on visual stimuli is a challenge of visual organization. More specifically, the organization that is likely given a certain set of objects (devices) and a desired understanding based on that organization. The goal was to try to isolate the various mechanisms (spatial encoders) that one might use to create a paired relationship between two Bluetooth devices. Although the resulting experimental study may emulate certain elements of a traditional Gestalt study, it differs in one particular perspective. Although the use of basic forms (black) was applied to a particular ground space (white), it was the participants that were constructing these patterns and relationships based on the three stimuli words (disengaged, engaged, connected). It was a top down process of 'encoding' spatial relationships versus a 'decoding' or interpretation of visual information. In many psychological studies related to perception the focus is that of 'decoding' the visual stimuli. The distinction is that the study outlined in this paper was a cognitive exercise as it relates to spatial organization. In doing so it was accounting for the fact that a user engaged in understanding his or her wireless environment and the relationships that lie within it, is not only concerned with identifying (decoding) the existing relationships (the speakers are paired to the TV) but also in creating (encoding) or directing new relationships. So isolating the mechanics of this type of relationship construction was the focus of that study. In combining what is known about perceptual organization with what was discovered about rectilinear pattern generation (primary work) a protocol was developed for how individuals devise relationships from visual patterns.

3. Description of research methodology and results

3.1 Basic study characteristics

This study's aim was to isolate how people utilize spatial organization of physical forms to create meaning. More specifically the study sought to identify patterns of spatial organization that could be used to further inform a tangible or gesture-based approach to creating Bluetooth pairings between two digital objects. Leveraging the physical form of the object could lead to an implicit interaction framework that would rely less on the explicit screen-based interfaces of mobile devices and more on the proximity and alignment of the physical form of the devices. To that end, this study focused on identifying the common patterns that are encoded by individuals when prompted to create a relationship between two specified forms. These forms were primitive shapes like circles, squares, and rectangles so as to not directly represent a known digital device. In doing so, the study aimed to eliminate as many independent factors as possible. The second experimental tool used in this study was a set of three words as stimuli. The words were; 'disengaged', 'engaged', and 'connected'. These words were representative of a relationship state to signify connecting two or more digital devices together via Bluetooth connection. Further review of the data collected as well as its implications can be found in the discussion section of the paper.

Sample Characteristics:

- Sample size: 12
- Gender: 50/50 (male/female)
- Mean age: 29 yrs.

Study set-up:

- One on one (researcher/participant), 30 minute personal interviews in isolated environment (Figure 1).

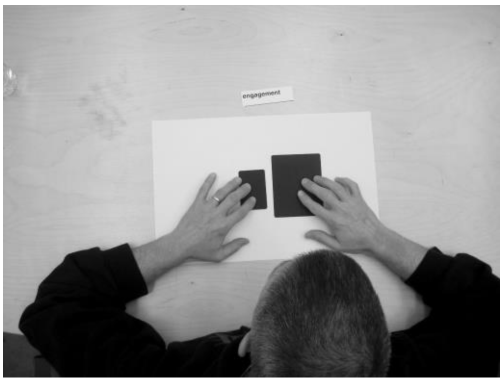

Figure 1. Study setup

3.2 Procedure and experimental tools

Participants were asked to arrange a given set of black forms (figure 2) on a white bounded space (279 x 432mm paper) based on a stimuli word. The forms could touch but not overlap or be placed outside of the bounded space (figure 3). For each form combination (treatment), one of three word stimuli was used at random and the given participant then had to position the individual forms so as to encode or create a representation of the word. This was repeated until all three word stimuli had a resulting pattern generated by the participant at which point a new set of forms was utilized and the word stimuli were administered again. Photographs were taken of each of the patterns generated so that they could be analysed later to identify similarities. There was a total number of 3 treatments or sets and 9 combinations (figure 4) that an individual participant could generate which resulted in a collection of 108 form combinations or patterns. The main focus of this exercise was to isolate the patterns from paired combinations between the small circles, squares, and rectangles. The goal in isolating these patterns was to determine how people utilize spatial characteristics to create visual pairings or relationships based on a set of actions (stimuli words). These actions were to evoke visual meaning for the potential different states one might desire in a Bluetooth pairing between two digital devices. The data and resulting insights from this study could then be utilized as a foundation for developing a tangible user interface approach to pairing protocols or gestures.

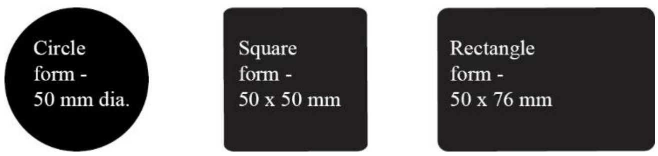

Figure 2. Form samples

Form combinations resulting in patterns (3 treatments / sets, 9 total combinations):

1. Two circles (same scale)
2. Two squares (same scale)
3. Two rectangles (same scale)

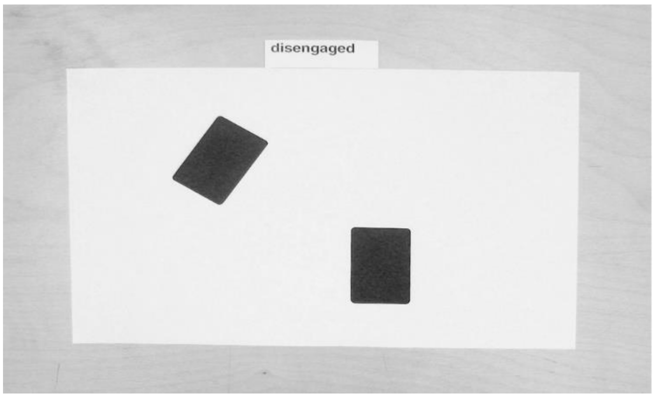

Figure 3. Sample of participant encoded form patterns (rectangle)

Word stimuli:

1. Disengaged
2. Engaged
3. Connected

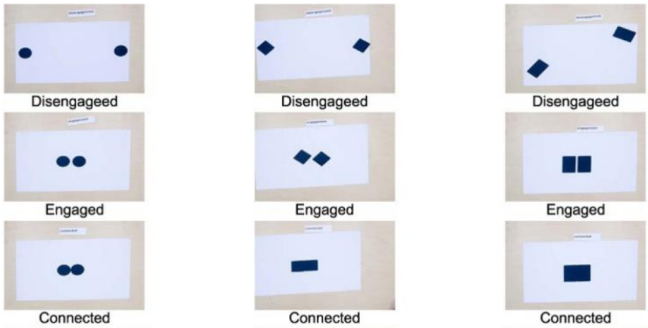

Figure 4. Sample data collection from one participant (3 treatments)

3.3 Results: Circular Forms

After completing the study and collecting all of the photographed data, analysis was first performed on the circular forms to identify common patterns of association based on word stimuli (disengaged, engaged, and connected). The circular forms allowed for a reduced number of variables to be examined. Circles on a flat plane do not have an 'orientation' component which allowed for 'proximity' to be the primary method for pattern differentiation.

Coding:

After common patterns were identified, a code was assigned to each pattern. The coded data was then applied to a frequency of distribution graph so as to highlight the main forms that were used to describe each action; engaged, disengaged, and connected. The resulting outcomes of the coded patterns for circular forms are depicted in figure 5, 6, and 7. Coding is as follows:

PD# = pattern, disengaged, number

PE# = pattern, engaged, number

PC# = pattern, connected, number

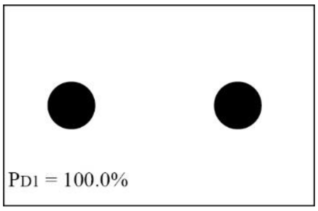

Figure 5. 'Disengaged' pattern results – circle forms

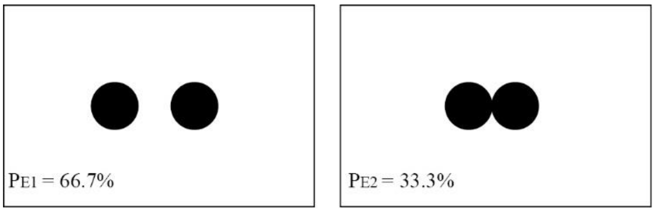

Figure 6. 'Engaged' pattern results – circle forms

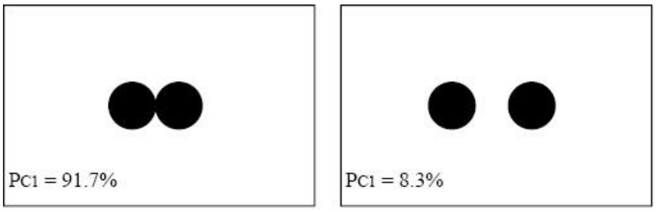

Figure 7. 'Connected' pattern results – circle forms

Circular forms – analysis:

The patterns generated by the participants served to isolate various attributes or mechanics that were used by individuals in responses to three stimuli; 1. Disengaged, 2. Engaged, and 3. Connected. These stimuli combined with the task of creating a patterned representation with the given shapes (circles, squares, and rectangles) provided constraining properties. Based on the collected data for the circular forms, the most dominate patterns that participants generated are shown in figure 8. In the case of the two circles and three word stimuli, the only way that participants could encode unique patterns for each word was to adjust the distance or 'proximity' between the forms as circles by their nature due not allow for alignment variation. Through this isolation and pattern analysis, participants responses showed a strong tendency to place circles at great distances from one another to represent disengagement and place the same circles either touching or at a reduced distance from each other to represent connected. As one pattern is not only an interpretation of the word stimuli (disengaged) but also relative to the other words that followed it (engaged, connected). The patterns have more meaning when compared to each other to denote a coded state. The relationships of the states through 'proximity' then becomes the primary mechanic (attribute) that participants used to translate the stimuli into structural forms. In isolation, proximity attributes can be interpreted as the following:

1. Disengaged = great distance of proximity
2. Engaged = reduce distance of proximity (from disengaged state)
3. Connected = further reduction of proximity / distance (from engaged state) to allow for touching surfaces

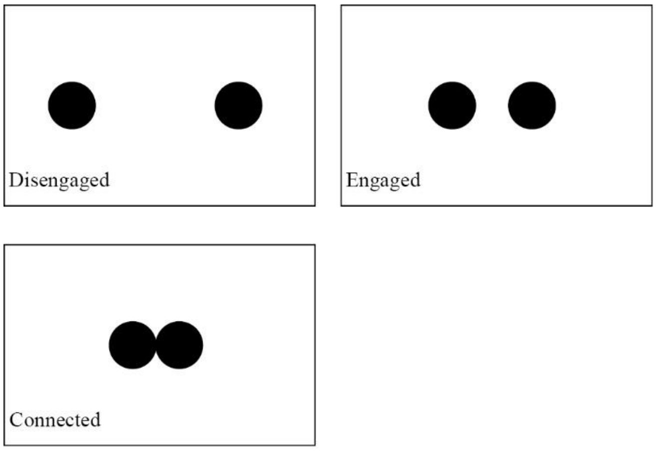

Figure 8. Most dominate patterns – circle forms

3.4 Results: Square Forms

The patterns generated by participants based on the two square forms and word stimuli were recorded and evaluated in the same manner as the circular forms. The resulting outcomes of the coded patterns for square forms are depicted in figure 9, 10, and 11. Coding used the same nomenclature as the circular form coding:

PD# = pattern, disengaged, number

PE# = pattern, engaged, number

PC# = pattern, connected, number

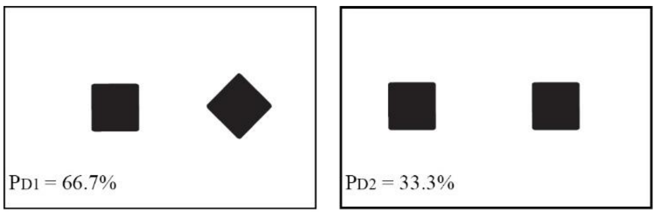

Figure 9. 'Disengaged' pattern results – square forms

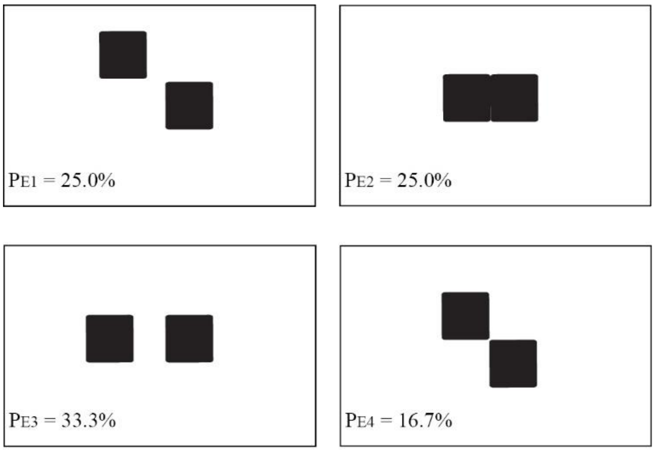

Figure 10. 'Engaged' pattern results – square forms

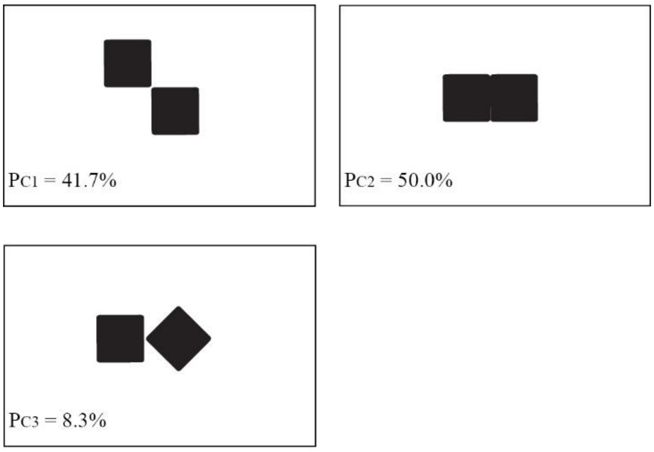

Figure 11. 'Connected' pattern results – square forms

Square forms – analysis:

The same exercise was repeated for two squares which introduced the possibility of alignment (orientation) as a mechanic that individuals could utilize in spatial encoding. After reviewing the square form combinations, there were no overly dominate patterns that were identified aside from the 'disengaged' treatment. As proximity and orientation could be utilized by participants in both the square forms and rectangular forms, it became more informative to evaluate the rectangular pattern data to identify potential insights.

3.5 Results: Rectangular Forms

The patterns generated by participants based on the two rectangular forms and word stimuli were recorded and evaluated in the same manner as the circular and square forms. The resulting outcomes of the coded patterns for square forms are depicted in figure 12, 13, and 14. Coding used the same nomenclature as the circular and square form coding:

PD# = pattern, disengaged, number

PE# = pattern, engaged, number

PC# = pattern, connected, number

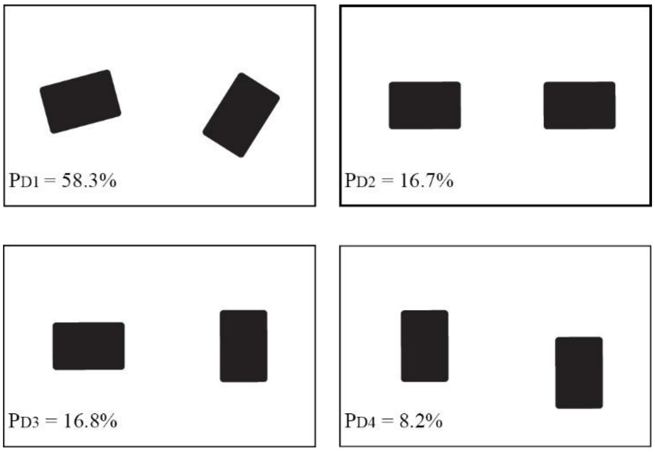

Figure 12. 'Disengaged' pattern results – rectangular forms

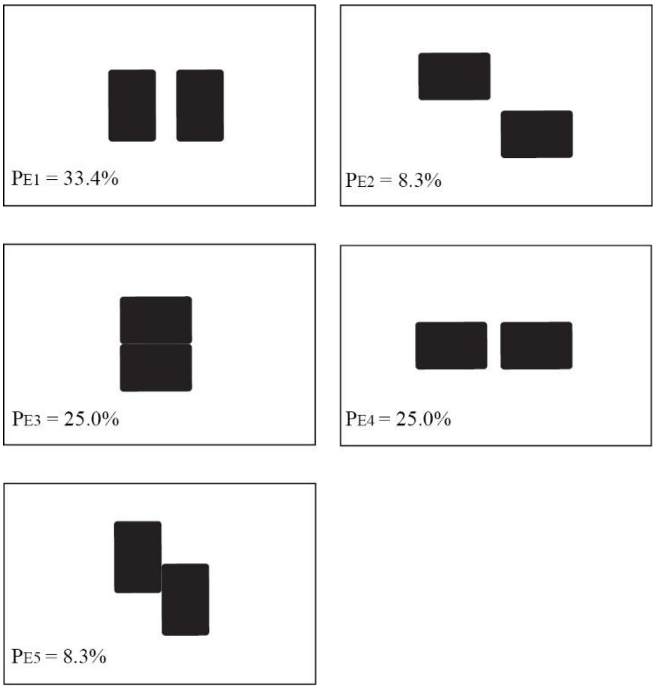

Figure 13. 'Engaged' pattern results – rectangular forms

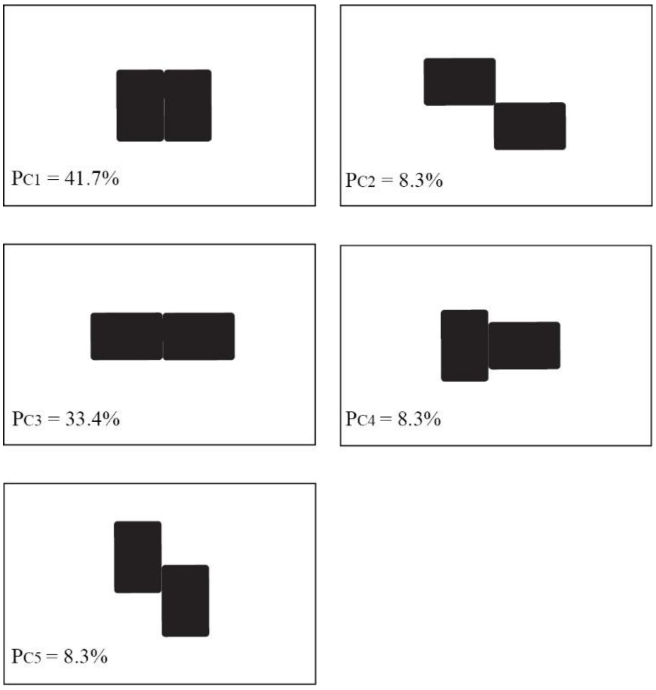

Figure 14. 'Connected' pattern results – rectangular forms

Rectangular forms – analysis:

Analysis was then performed on the rectangular forms to identify common patterns of association based on word stimuli (disengaged, engaged, and connected). With the rectangular forms there were two potential mechanics for participants to use in the generation process; 1. Proximity and 2. Orientation. As the circular forms helped to define a protocol for proximity, the aim was to use the rectangular forms to gain insight on how orientation is used to denote various states. The most common patterns produced by participants are depicted in figure 15.

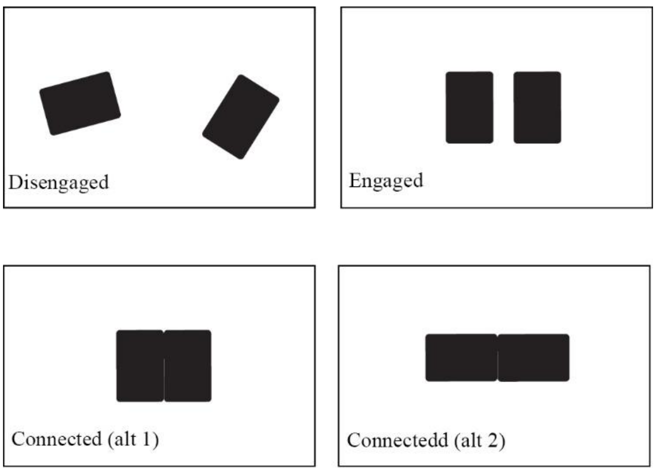

Figure 15. Most dominate patterns – rectangular forms

All forms – analysis:

Although there was a great variety in the patterns that participants produced based on any given stimuli (Table 1), there were similarities among the characteristics of a set of patterns. If one reviews the patterns generated for "disengaged", it is apparent that proximity / distance is the major underlying mechanic that was used by participants to denote that state. Additionally, 58% of respondents utilized misalignment of edges as an orientation characteristic for "disengaged" while the other 42% used some form of alignment. Again, in the "engaged" set of form patterns there is a consistent use of proximity (reduced from disengaged). This reduction of distance between the two forms resulted in closure and in some cases touching surfaces. Orientation varied with respect to any one particular pattern but the consistent element between them all was the alignment of edges which 100% of the respondents produced. "Connected" showed continued utilization of proximity, with all respondents producing touching forms and reduction of distance from "engaged" state to "connected" state. Additionally, all forms showed patterns of aligned edges with respect to their orientation. The majority of participants (75%), produced aligned patterns of shared similar edges.

Table 1 Responses to Form Generation

		Circular Forms		Square Forms		Rectangular Forms	
		Response	% of total	Response	% of total	Response	% of total
Disengaged	P_{D1}	12	100	8	66.7	7	58.3
	P_{D2}			4	33.3	2	16.7
	P_{D3}					2	16.7
	P_{D4}					1	8.3
Engaged	P_{E1}	8	66.7	3	25	4	33.4
	P_{E2}	4	33.3	3	25	1	8.3
	P_{E3}			4	33.3	3	25
	P_{E4}			2	16.7	3	25
	P_{E5}					1	8.3
Connected	P_{C1}	11	91.7	5	41.7	5	41.7
	P_{C2}	1	8.3	6	50	1	8.3
	P_{C3}			1	8.3	4	33.4
	P_{C4}					1	8.3
	P_{C5}					1	8.3

Based on the collected data and examined patterns, orientation protocols can be interpreted as the following:

1. Disengaged = misalignment of edges and distance
2. Engaged = alignment of edges and reduced distance (from disengaged state)
3. Connected = alignment of similar edges and further reduction of proximity / distance (from engaged state) to allow for touching surfaces

4. Discussion and Expanded Theoretical Background

4.1 Summary of form generations

The patterns generated by the participants served to isolate various attributes or mechanics that were used by individuals in responses to three stimuli; 1. Disengaged, 2. Engaged, and 3. Connected. These stimuli combined with the task of creating a patterned representation with the given shapes (circles, squares, and rectangles) provided constraining properties. In the case of the two circles and three word stimuli, the only way that participants could encode unique patterns for each word was to adjust the distance between the shapes as circles by their nature due not allow for alignment variation. Through this isolation and pattern analysis, participants' responses showed a strong tendency to place circles at great distances from one another to represent disengagement and place the same circles either touching or at a reduced distance from each other to represent connected (figure 8). This identified *'proximity'* as an attribute for encoding relationships (disengaged, engaged, and connected).

The same exercise was repeated for two squares which introduced the possibility of alignment (orientation) as a mechanic that individuals could utilize in spatial encoding. After analysis was complete, there was an increased tendency for both proximity and orientation to be used in creating patterns for each task. Again, proximity was by far the leading mechanic and some form of alignment was event. Like the circles, the squares were place at greatest distance for disengaged and the closest distance (or touching edges) for connected. The orientation of the squares was non-aligned for disengaged and aligned (or touch common edges) for connected.

Ultimately, the final set of patterns that came to be analysed were the rectangle pairs. The findings reflected those of the squares but in this case the participants had the increased latitude of being able to orientate either short or long edges. Both distance and edge alignment were consistently produced in response to the task of assigning patterns for the three stimuli words. One point of difference between the square exercise and the rectangular one was that the majority of the participants completed the final connection pattern with two long edges aligned and touching. Based on these final outcomes, both *'proximity'* and *'orientation'* were the two main attributes used in spatial encoding based on the constraints of the study and *'proximity'* was more dominate that *'orientation'* as a system for conveying various states in a pattern relationship.

4.2 Theories in spatial hierarchy

Having isolated the two attributes of *'proximity'* and *'orientation'* from the primary study this research then examined these finds and how they might integrate with other theoretical visual organization laws. Grouping plays a significant role in visually identifying relationships and acts as a way of dividing an environment or perceptual field into natural units (Pomerantz, 1981). These natural units are spontaneously assessed by the observer as a means to identification for potential action. Researchers agree that simplification via grouping of one's visual environment is used to ascertain the perceived properties of a given pattern or set of patterns (Rock, Indirect Preception, 1997). Traditionally there are three main classifications of these phenomena; 1. organization of space, 2. of shape / form, and 3. of movement. In each case these are attributed the being the most likely factors that will influence grouping. Space as a constraint is described by size (scale), distance, slant (orientation or alignment). Shape / form is the outline or silhouette of the object and form is the volumetric attributes that the shape has. Movement being the transformation of an object through a visible space not to be confused with the motion parallax that occurs when an observer moves through a space (Hochberg, 1981). In Gestalt grouping there is a division of two factors that influence tendencies of association in combination with the base concept of figure-ground. The first is the 'Laws of Grouping' (Rock, Perception, 1984) which would include similarity, proximity, or common fate as well as other specific types of grouping phenomena and the other factor is the concept of Pragnanz or good continuation. Pragnanz is a factor that states that the "visual field will group so as to yield the best, most stable organization" (Pomerantz, 1981).

Upon review of these laws, both proximity and similarity (orientation) are present in the previous primary study but the question arises, how do these fit within a greater hierarchy of visual organization? To address not only the concept of grouping but the potential of hierarchies within grouping, this theoretical examination moved beyond the basic Gestalt laws and examine the works of researchers that have pursued further study in this arena of spontaneous visual organization.

One researcher that has spent a significant amount of time studying and refining potential hierarchies within the Gestalt principles of grouping is Stephen Palmer (UC, Berkeley). Concerned with reviewing the laws of grouping that Gestalt had developed at the begin of the 20th century, he found these laws to be useful in describing certain phenomena but had issues with the limits of these laws in accounting for multiple factors in the perceptual process. Specifically he describes two major difficulties with Gestalt at the time of his proposed theory… *"1. Their (Gestalt) laws are purely qualitative and 2 that they never suggested ways in which the different factors could be integrated"* (Palmer, 1982). In an effort to better address these concerns, he proposed a "Transformational Theory of Perceptual Structure" that was partially focused on the use 'spatial analysers' within a visual system. Palmer used the term 'spatial analyser' to refer to the brains ability to aggregate and organize spatial information given by a set of sensory elements within a certain visual field or 'sensory mosaic' (Palmer, 1982).

> "…spatial analyser is a computational abstraction - a black box if you will - whose inner workings and physical realization do not concern us. When we discuss an analyser, then, we are really talking about a function computed over space by a hypothetical device." (Palmer, 1982)

Within this examination of spatial analysers, Palmer proposes that the way they operate within the visual system can be categorized by position, orientation, sense, and resolution. Additionally, he went on to develop an ordering system or level for the various analysers. First, Second, and Third order analysers are composed of the following; First Order is the attention to static elements within a sensory mosaic - position, orientation, and size. Second Order analysers are related to motion (displacement) and rate (velocity) and Third Order analysers are utilized in examining acceleration. Most of Palmers theory is perhaps far too detailed for the purposes of this discuss but this foundational work was informative with particular focus on first order analysers as they relate to position, orientation, sense (size), and resolution. He uses these factors as they relate generally to the established Gestalt laws and compares how they may interact in a given set of stimuli. Meaning what are the predominate factors, what are their potential order of influence, and how do these interact with each other?

Palmer's work would indicate that "spatial proximity is perhaps the most basic organizational factor" (Palmer, 1982). Proximity is a relative characteristic and that is where the resolution of that proximity comes into place. Resolution being the intensity of interactiveness or the distance that a set of patterns is in relation to another pattern. Take for example the case of displaying a triangle, a square, and a circle which all have different shape and potential orientation indicators. If the square and the circle are place in close proximity to each other and the rectangle is placed at a significant distance from the first two then the circle and square will be grouped with each other thus implying that the spatial distance is a stronger indicator of grouping that the shape or orientation of a given visual array. All this is to point to the fact that proximity is often the dominate factor in decoding spatial relationships (Palmer, 1982). Palmer makes clear that although proximity tends to be the most basic organizational factor it is almost always a case of relative magnitude.

> "Whether orientational grouping would dominate proximity grouping is clearly a matter of the relative magnitude of each sort of relatedness. If the orientational difference is small and the positional difference is large, the proximity should dominate. The opposite situation should produce the opposite result." (Palmer, 1982)

As Palmer theory is elaborated, he references the research work of Beck (1966) to address the relative dominance of orientation over shape. In Beck's experiments, he showed that the tendency of orientation (T shapes vs. L shapes) as a more powerful organizer that the shape of the actual stimuli. From these and other experiments, Beck showed that at least for these particular conditions that orientation leads shape similarity in a hierarchy of grouping. This is not to say that shape similarity and comparison of that similarity is lacking in its potential impact on grouping but simply to say that the tendency is for orientation to be the dominate factor. In addition, orientation can serve to effect the perception of two similar shapes (Rock, Perception, 1984). If similar shapes are at a different orientations this can have a tendency to lead to inaccurate shape perception; in this case the alignment of orientation can improve the power of form similarity on perceptual grouping. To isolate the impact of shape comes down to the invariant structures that lie within a given shape.

Invariants are typically described as quite simply the qualities of an object or stimulus pattern that do not vary or remain constant in proportion and relationship to each other (Gibson, 1979). When multiple shapes are compared in a visual grouping scenario, the invariants proved additional discriminating input to the perceiver that allows for an additional level of organization (Palmer, 1982).

4.3 Perceptual protocol for encoding relationships

Palmer's Transformational Theory of Perceptual Structure is much larger than the elements that were highlighted in this paper and tend to encompass theory from not only Gestalt but Ecological and Information Processing psychology. It also examines the role of motion (both environmental and observational) as the title implies. Considering the elements that I have selected from his work for this discussion it is important to note the ordering within grouping that this theory proposes if only at a first order. In first order spatial analysis (static), position (proximity) leads orientation which in turn has a stronger influence on organization when compared to form similarity (shape). Within form similarity, the invariants of a particular shape can have an additional influence on organization as well. The summary in spatial hierarchy combined with the findings from the primary study, were then visualize in a bottom-up pyramid as a way of establishing a 'perceptual protocol' resulting in an encoding process between physical objects to create the meaning of relationship or connection (figure 16).

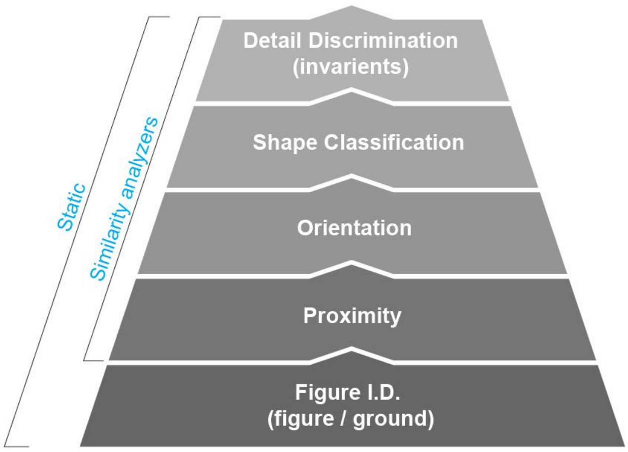

Figure 16. Perceptual pyramid for encoding spatial relationships

The previous discussion was an effort to examine various perceptual theories and how they could be applied to a digital device relationship encoding process. The aim is that this process will be useful in creating an approach to designing qualities that may aid in the user's understanding of wireless relationships.

5. Limitations

The challenge to this study was to identify how users can create through action the relationship state that they desire between two Bluetooth devices. To that end, it was important to isolate the mechanics that participants utilized in spatial encoding. If it were merely a study of perception and not action then the study could have focused solely on visual grouping and the factors that influence the inclination of these groupings in a bottom-up process (lower order leading to higher order cognition). For this reason, it was important to have participants create *spatial generations* (patterns) based on word stimuli versus having them describe *spatial analysis* based on form stimuli. That being said, the insights resulting from this experiment coupled with the theoretical foundations in perception can be considered descriptive and direction in nature. These could be enhanced through the replication of this study on a larger sample size. Additional factors that could have directly influenced the findings were the constrained nature of the primitive forms used in this study (circle, square, rectangle) as they were predominately flat and void of a vertical dimension. Lastly, the alignments in orientation that the participants created could potentially be attributed to the environmental constraint of a rectilinear piece of paper. This rectangular paper could have directly affected the participants form generation as it implicitly provides orientation that contributes to the overall mapped relationship between two forms and their environment.

6. Conclusion

With increasing shift from a wired to wireless world, there has been a loss in the visual mapping that these wires once represented. This representation is that of connection and relationship between two or more digital objects. As this wireless ad hoc world continued to expand, design must play a role in utilizing the physical and tangible qualities of objects to create a new semantic approach to pairing. This studies aim was to provide insights into the mechanics or attributes that participants utilize in creating paired relationships between objects for the purposes of informing a tangible approach to creating paired relationships between Bluetooth devices. The resulting findings from the primary study indicated that ‘proximity’ and ‘orientation’ were the key drivers that individuals utilized in encoding relationship qualities between two forms. The previous deep dive into spatial organization and visual perception was an effort to couple the findings from the primary study with additional theory so as to propose a foundational protocol or framework for encoding relationships between Bluetooth digital objects. Utilizing these study findings and perceptual theory as a means of informing a new way of leveraging the gestures or spatial relationships to define what is connected in an ever expanding wireless world. This proposed protocol could serve as a foundation for designers as they continue to develop new tangible interactions between objects and users.

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