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A Literature Review of the Universal and Atomic Elements of Complex Cognition

Derek Cabrera[a,b,@], Laura Cabrera[a,b], and Elena Cabrera[a,b]
a: Cornell University
b: Cabrera Research Lab
@: dac66@cornell.edu

1. DSRP Theory: Simple Rules that Underlie Complex Cognition

DSRP theory articulates how we build meaning of concepts and how knowledge is created. Additionally, DSRP highlights how thinking and knowledge evolve. This paper offers two important and new insights about complex cognition. First, it articulates the foundational building blocks of thoughts—cognitive structures that underlie *thinking* and *learning*. These underlying structures are identified as four simple rules detailed in Table 1 below.

The Identity-Other Distinctions Rule	
$D := (i \leftrightarrow o)$	A Distinction (D) is defined as an *identity* (i) co-implying an *other* (o)
The Part-Whole Systems Rule	
$S := (p \leftrightarrow w)$	A System (S) is defined as a *part* (p) co-implying a *whole* (w)
The Action-Reaction Relationships Rule	
$R := (a \leftrightarrow r)$	A Relationship (R) is defined as an *action* (a) co-implying a *reaction* (r)
The Point-View Perspectives Rule	
$P := (p \leftrightarrow v)$	A Perspective (P) is defined as a *point* (p) co-implying a *view* (v)

Table 1. The foundational building blocks of thought.

These structures underlie more complex cognitive structures such as categories, concepts, schema, and mental models. The second thing DSRP Theory explicates is the dynamics (the complex of interactions) that these 4 structural patterns of thought generate. DSRP explicates 4 simple rules that interact with one another inextricably. For example, any idea is simultaneously: a distinct (D) manifested in it’s label or identity; a system (S) that has parts (and can be part of a larger whole; related (R) to other ideas or things around it; and can be a perspective (P) on other ideas or things (e.g., a person in a network or a concept on another concept like sustainability as a perspective on a policy solution). Thus while the structures themselves are simple and easily understood, the dynamics among them yield considerable power to cognition, understanding, learning, and the evolution of knowledge itself.

2. Identity-Other Distinctions

Distinction-making (D) is the act of distinguishing among ideas or things. In other words, explicitly delineating a concept or thing the "identity" and therefore, often implicitly, other concept(s) or thing(s) become the "other." Infants show evidence of distinction-making in the womb and object-oriented distinction-making as early as three months of age, while experiments with adults show the varied and sophisticated ways distinctions are made across the lifespan. A review of peer-reviewed journals across disciplines indicates:

1. The existence of Distinctions (i.e., D as a noun);
2. The act of Distinction making (i.e., D as a verb);
3. That the relationship between "identity" and "other" (i.e., D(i ↔ o) is elemental to (1) and (2) above; and,
4. That the human tendency toward identification without the conscious or metacognitive recognition of the other (i.e., where the "other" remains implicit), leads to opportunity costs and marginalization. Alternatively, the purposeful and explicit identification of the other (i.e., where the "other" is made explicit) can lead to marginalization and stigmatization.
5. In summary, the literature shows that items 1-4 are fundamental "patterns of mind" agnostic to the content they are within and are seen throughout the lifespan of humans. Yet, where Distinction making is concerned, the difference between thinking (ie., cognition) and systems thinking (i.e., systematic metacognition) is not in the $D(i \leftrightarrow o)$ structure of cognition itself, but in the willful and purposeful attempt to see (i.e., be aware of) the D(i ↔ o) structure that is at work when thinking.

A: Distinctions Exist in Both Mind and Nature

Distinctions exist in our minds and in nature. They are both real and conceptual and sometimes the real are in alignment with the conceptual (e.g., we see things as they are). Distinction-making is a universal cognitive structure, as we cannot think a thought, without also making a distinction. G. Spencer Brown [1] opens his book, *Laws Of Form* (1969) with:

> "The theme of this book is that a universe comes into being when a space is severed or taken apart. The skin of a living organism cuts off an outside from an inside. So does the circumference of a circle in a plane. By tracing the way we represent such a severance, we can begin to reconstruct, with an accuracy and coverage that appear almost uncanny, the basic forms underlying linguistic, mathematical, physical, and biological science, and can begin to see how the familiar laws of our own experience follow inexorably from the original act of severance. The act is itself already remembered, even if unconsciously, as our first attempt to distinguish different things in a world where, in the first place, the boundaries can be drawn anywhere we please."

Understanding that objects have boundaries and that we create borders to understand the way the world works is a powerful idea that deepens our understanding of reality. Distinctions exist in the real world and in the mind. Often we strive for coherence between reality and the mind to align our thinking with the reality of how things exist in the world.

Theoretical physicist, Lawrence Krauss, Director of the Origins Project at Arizona State University and author of "A Universe From Nothing" explains the reason there is something rather than nothing is simply that “nothing is unstable” [2] and that if one waits long enough something will emerge from nothing. He states,

> “Once you combine quantum mechanics and relativity, empty space, which apparently of course is nothing, it is not so simple. It's actually a boiling, bubbling brew of virtual particles popping in and out of existence, in a time scale so short you can't see them. And in fact, if you wait long enough, and allow gravity to operate empty space will eventually start producing particles.”

Ergo, something exists as part of the real world or universe, or reality. That *something* is of course many things today, and the backdrop for either the entirety of that something is *nothing*. At the same time, if we were to single out one of the parts of that aggregate something the backdrop for any element is not only nothing, but all the other somethings which are not that thing. Of course, what we single out with our mind’s eye may be in alignment with something real and discrete in the universe, but it may also be a figment of our imagination or an approximation of something real that is so flawed as to be a heavily biased version of it. Regardless, distinguishable entities exist—whether in the natural or “real” world or in the mind (i.e., conceptual entities) or both.

Leonid Euler [3] incidentally discovered graph theory and spawned modern day network theory during his effort to solve one of the perplexing problems of 18th century Prussian society. In the “Seven Bridges of Königsberg” problem, there are two islands connected to the mainland by seven bridges (Figure 1). The problem was to determine if it was possible to go on a walk through the city that crossed each of the seven bridges once and only once. Euler, using the power of abstraction, discovered that the Königsberg problem had no solution but in doing so he launched modern network theory.

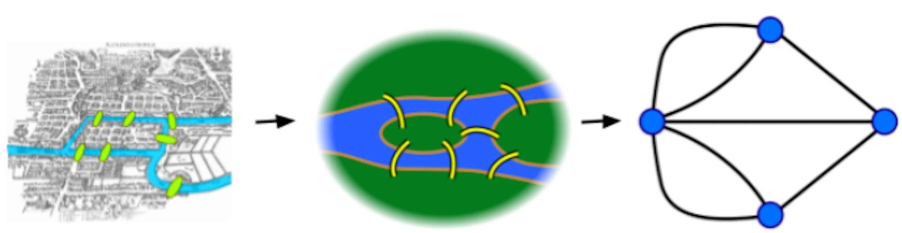

Figure 1: Euler abstracted the problem to a set of nodes and edges and launched network theory.

Today networks are a ubiquitous modeling tool that crosses the physical, natural, and social sciences, as well as business and commerce. Networks are both ubiquitous structures in nature and powerful tools of the mind for understanding nature better. Figure 2 illustrates a sampling of such networks: (left to right, top to bottom) abstract, political, food web, corruption, ecological, computer, corporate, disease, conceptual, terrorism, social, and human trafficking. Taking Euler's cue on the value of abstraction, what we see across all of these networks is simply that there are things, which are called nodes in network theory. Nodes represent things (*identities*) of all shapes and sizes, from abstract ideas, to people, to groups of people, animals, corporations, words, computers, terrorists, senators, and so on. If it's a thing, it can be a node. In short, networks—both in the real world and in our mind are made up of things (*identities*) represented as nodes in the network. The nodes exist with *other* nodes, which they are differentiated from by virtue of their own nodeness. Those *other* nodes provide the backdrop or context for any individual node (*identity*). Indeed, in any given network, in order to fully define any given node, one must not only identify that node's (label, name, status, etc) but also that of the other nodes it is with. Thus, the other nodes provide context for the node itself, and this occurs simultaneously for all nodes in the network.

DSRP Theory advances modern day network theory by offering a complete definition of any given node: what the node is (it's distinguishing characteristics, ID, label, position, etc.) and also what the node isn't (i.e., the other nodes it is with). This is critically important, because, as you will see, the mind does not merely form concepts based only on positive affirmations of a thing, but also on the negation of a thing. A *car* is *not-a-duck* and also *not-a-refrigerator*, but closer to its definition, it is also *not-a-truck*. The concepts we form exist within a network of similar and different concepts and are heavily dependent on the *affirmation* of identity but also the *negation* of it.

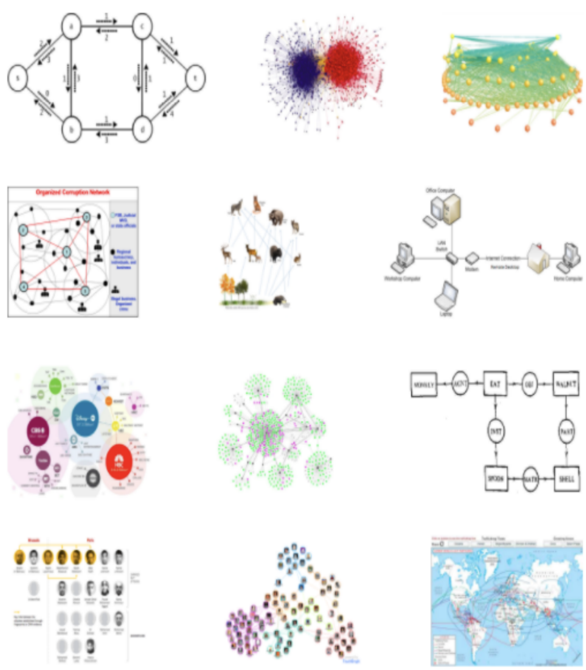

Figure 2: Networks of all kinds.

Kolata 1984 [4] studied learning while in utero. In the past, researchers thought that an infant's world was incredibly confusing and overwhelming, but it is becoming increasingly clear that infants are familiarized with their environment from day one. This means that infants are learning while developing in the mother's womb. She wrote that, "They [infants] can discriminate between objects that they can see and even recognize their mother's voice." Infants can Distinguish, from birth, their caregiver's voices. Some studies showed that babies recognize and show a preference for poems or stories that were read to them while developing in the womb. The fetus has a unique *Perspective* on their in-utero world of sounds and stimulations. The fetus draws *Relationships* between the sounds of voices to sources and responds more positively, after birth, to its mother's voice. Evidence that fetuses form Distinctions before they encounter the complexity of the world forwards the assertion that Distinction-making is an *innate* process possessed by human beings. In fact, whenever researchers look for evidence of fetal learning, they find it.

Partanen et al. [5] utilized EEG technology to access fetal memories within infants. They gave expectant mothers a recording to play to their fetuses multiple times a week. The recording was a loop of a made-up word ("tatata"). At birth, the infants had heard the made-up word over 25,000 times. Amazingly, when the infants were tested at birth **and** at 4 months of age, they neurologically *Distinguished* the word. Fetuses can form Distinctions and they can remember and utilize those Distinctions to eventually learn language. DSRP is fundamental to learning. While fetuses are in utero, they are developing the ability to make *Distinctions, Systems, Relationships,* and *Perspectives*, which sets them up for a lifetime of learning.

An innate process possessed by humans leads one to explore when humans develop this skill and how it can be ascertained. In 1997, Quinn et. al. 1997 [6] completed two studies on 97 healthy infants between three and four months old. In Experiment 1, an embedded figure task was used to determine whether three and four month-old infants organize visual pattern information in accord with the good continuation principle which simply means that humans tend to see a line as continuing in the direction in which it is set[1].

Two experimental groups were familiarized with a complex pattern shown in Figure 3.

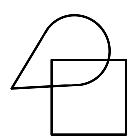

Figure 3: Pattern used in Experiment 1.

To determine whether infants could parse and organize the pattern in Figure 3 into two distinct shapes (a teardrop and a square) one experimental group was presented with a teardrop shape and a number 4 immediately following familiarization. In the experimental group, 17 out of 24 infants showed a preference for the “4” at a preference rating of over 50%, while in the control group (those who had not seen the number 4 alongside the teardrop), only 4 out of 24 infants showed a preference for the “4” at a preference rating of over 50%. These results indicate that the experimental group of infants who had seen the teardrop before, saw the number “4” a novel visual stimulus—catching their attention and preference. This preference indicates that the infants were able to Distinguish pattern into two Distinct shapes.

A second experimental group was presented with a square shape and a number 4 immediately following familiarization. In this experimental group, 22 out of 24 infants showed a preference for the “4” at a preference rating of over 50%, while in the control group (those who had not seen a 4), 14 out of 24

[1]The “good continuation principle” refers to the Gestalt organization principle that humans have an innate tendency to perceive a line as continuing in the established direction of the line.

infants showed a preference for the "4" at a preference rating of over 50%. Further, these results indicate that the experimental group of infants who had seen the square shape before were able to Distinguish the above pattern into two Distinct shapes.

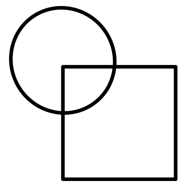

Figure 4: Pattern used in Experiment 2.

According to the authors the experiment showed, "a finding consistent with the notion that infants' adherence to the good continuation principle facilitated organization of the region containing the contours of the square into the square shape." These results from both groups in Experiment 1 confirm that some degree of habituation to the familiar stimulus occurred in both experimental groups.

In the second experiment, three- and four-month-old infants in an experimental group were initially familiarized with the stimulus in Figure 4.

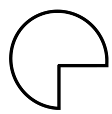

Figure 5: Shape P1.

To determine whether the infants organize the familiar stimulus information into two separate shapes—the circle and the square—the experimental group was given two preference tests immediately following familiarization, one of which paired the circle with shape Pl shown in Figure 5. And the other pairing the square with P2 shown in Figure 6.

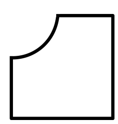

Figure 6: Shape P2.

In the experimental group for the second study, 16 out of 24 infants showed a preference for the shape P1 over the circle at a preference rating of over 50%, while in the control group, 11 out of 24 infants showed a preference for the shape P1 over the circle at a preference rating of over 50%. For the square condition, in the experimental group, 22 out of 24 infants showed a preference for the shape P2 at a preference rating of over 50%, while in the control group, 16 out of 24 infants showed a preference for the shape P2 at a preference rating of over 50%. These results indicate that after familiarization infants preferred the novel shapes (P1 and P2) over the separated pattern stimulus (a circle and a square). This means that the infants were able to take a combined shape and separate out the Distinct shapes it was made of. The results of the experiment, “indicates that infants habituated, at least to some degree, to the familiar stimulus configuration.” Overall, the study states that, “the present research has extended these findings by demonstrating that infants can also parse and organize the more complex pattern information in a set of intersecting contours into two complete shapes.” This evidence suggests that three to four month old infants are capable of extracting relationships from a set of patterns, which provides for concept formation[2]. The authors concluded that “infants from a very early age, perhaps even from birth, are able to organize a variety of stimulus configurations into coherent shapes and forms.” They stressed that this didn’t mean that infants perceived all aspects of a scene in an organized manner. It does confirm, however, that from an early age, the human brain Distinguishes between different patterns and shapes, even if the two shapes overlap. Even in cases where two or more forms clearly overlap, the human brain interprets them in a way that allows people to differentiate different patterns and/or shapes.

As Quinn et al shows, young infants visually distinguish among objects with some skill. Studies on aural distinctions made by infants also explore another sensory mode of distinguishing sounds. Newman and Jusczyk (1996) [7] studied the brain’s ability to separate one sound (i.e., your name at a cocktail party) from many competing background sounds (known as the “cocktail party effect.” This phenomena has been studied in adults, but their studies showed that infants as young as 7.5 months old separate particular sounds from competing sounds. Their first three experiments were designed to test if infants at or around the age of 7.5 months were able to attend to a target voice that was either 10 dB, 5 dB, or 0 dB more intense than a competing background voice. The researchers hypothesized that if infants were able to separate competing layers of speech, they would listen longer to “fluent speech passages” that contain words they heard in the familiarization trial.

For the first experiment, 24 infants at ~7.5 months of age were tested. They went through a familiarization trial, where they were familiarized with their target words. They were then tested with four, 6-sentence passages (known in text as “Cup”, “Dog”, “Feet”, and “Bike”) that were read and recorded by a woman speaking in a “lively” tone. The familiarized target words were dispersed throughout the passages, and were not necessarily emphasized in the passage. For the distractor recording, a non-lively male voice was used, and when the two recordings were played, the distractor passage was set at 10 dB lower than the target recording. Half of the infants were assigned to the “Cup and Dog” familiarization trials, while the other half were assigned to the “Feet and Bike” familiarization trials. The two recordings were played while the infant was looking at a blinking red light, and the recording stopped when the infant looked away for two consecutive seconds (to indicate that they were no longer listening). The results showed that 21 out of 24 infants listened longer to the passages containing familiar words. The infants listened to the familiar passages for an average of 7.71 seconds, and the unfamiliar ones for an average of 6.21 seconds. “These results suggest that infants are capable of separating different streams of speech and are capable of listening selectively.”

For the second experiment the only change in the method was that the distractor passage was reduced to 5 dB lower than the target passage. All other experimental conditions were the same, including the sample of 24 infants aged ~7.5 months. In this second experiment 18 of 24 infants listened longer to the passages

[2]Also known as “prototype representation” - a complex form of pattern processing that may provide a basis for early concept formation.

containing familiar words. The infants listened to the familiar passages for an average of 8.01 seconds, and only listened to the unfamiliar passages for an average of 6.90 seconds.

In the third experiment the distractor passage was changed to 0 dB lower than the target passage. The results for this experiment differed from the previous two, in that only 10 of 24 infants listened longer to the passages containing familiar words. In addition, the amount of time devoted to each passage was not as different in length, as the infants listened to the familiar passages for an average of 6.74 seconds, and the unfamiliar ones for an average of 6.65 seconds. The authors wrote, “In contrast to the results of Experiments 1 and 2, there was no evidence that the infants recognized the similarity between the words in the test passages and the words that had been presented in isolation during the familiarization phase.”

For their fourth experiment, the general method was the same as the other three experiments, however during the familiarization trials, the infants were exposed to the target passages along with the distractor recording. They then were introduced to the target words for the experimental tests. They still had 24 infants of ~7.5 months of age. The results were that only 11 of 24 infants listened longer to the lists containing familiar words. However, the infants listened to the familiar lists for an average of 11.34 seconds, and the unfamiliar ones for an average of 9.85 seconds, which is significantly longer than the first three experiments.

These experiments indicate that infants can identify the sound they are interested in from other sounds competing with their target sound. This implies that the ability to make auditory distinctions (to identify one sound from other surrounding sounds) happens at a very young age and opens up more questions about the innateness of the Distinction pattern of mind in all sensory input mechanisms.

Gautheir and Tarr 1997 [8] worked with computer generated things called “greebles.” These were created in order to test different aspects of facial recognition processes in humans. In their experiment, they worked with 32 Yale University undergraduates. They generated 60 of the “greebles” (Figure 7), which are organized into five families and two genders based on the physical configuration of the generated greeble.

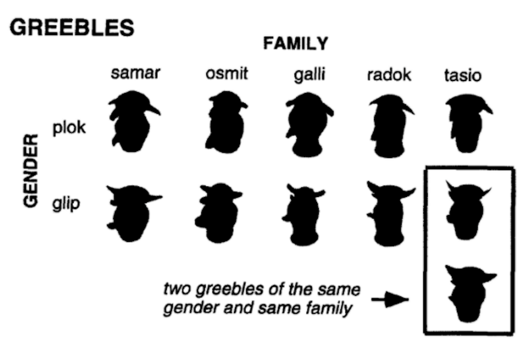

Figure 7: Examples of the greeble families and genders.

Each individual is unique, even though some might look as if they are quite similar. 30 of the generated greebles were used in the expertise training, while 24 of the unused ones were used for both the novice-level and expertise-level test phases. They designated “nonsense words” to call the five families, two genders, and each individual greeble. 16 of the participants were "experts" and 16 were "novices." The novice test group were only given the names of the 3 greeble parts: boges, quiff, and dunth (Figure 8).

Figure 8: The parts of the greeble.

No extra training was given to the novice group. They then were shown 6 novel greebles with a quick flash of their names (1 second) for 36 trials. Afterwards, the participants were given a forced-choice recognition of the parts. This was done in the form of a greeble's name and part was shown on the screen (e.g. Pimo's Boges) and the participants were asked to identify the part.
There were three conditions for this test:

1. "Studied-configuration: the two choices were the specified part and a foil part, both in the context of the Greeble specified in the prompt;
2. Transformed-configuration: the two choices were of the specified part and a foil part, both in the context of the Greeble specified in the prompt but with the top parts moved 15 deg towards the front;
3. Isolated-part: the two choices were of the specified part and a foil part, both in isolation on the screen."

The same procedure was done with inverted greebles afterwards. If the participants were in the "expert" test group, then they were given extensive training to make them experts at greeble recognition. This was done by having them practice greeble recognition at the family, gender, and individual levels with 30 different greebles. They then had to do 60 trials in which they verified their experts status by labelling novel greebles. The participants did 360 randomized trials where their response time and accuracy was collected. On average, those in the expert category responded more accurately and faster than those in the novice groups. Their results indicate that the more exposure one has to fine-tuned and novel distinctions, the better they will be at recognizing them. This is significant for the universal patterns of thought as it implies that the more aware that one is of the Distinctions around them, the more accurate and quick they will be at recognizing and thinking with them.

The ability to make auditory distinctions has been examined in more than humans. Aubin and Jouventin 1998 [9] researched the cocktail party effect within king penguin colonies. The ability to Distinguish parental calls from the calls of the other adult penguins is essential to a chick's survival, as king penguins breed in colonies of several thousand individuals. There are many factors simultaneously happening as the parent birds call their chicks, including all the other parents calling for their chicks, the calls of other birds, and background noise. They hypothesized that the chicks would have to be within a distance of 8-9 meters to make the needed auditory distinctions, however, their results showed that a much greater distance of 11 meters was possible. They observed and measured approximately 40,000 pairs of adults and around 1,500 chicks and recorded and analyzed the frequency and sound pressure level of the adult penguin pairs. They followed and recorded the birds until they met up with their chick. They then tested the chick's response to those recordings and noted behavioral changes in the chick when it recognized its parent's call. Usually, the chick "turned its head in the direction of the signal source, called in reply, and then approached (often running) directly towards the loudspeaker." Notably, the other chicks in the vicinity did not react to the call. This research demonstrates that the ability to distinguish is not only a human one, but is also seen in other species of animals (including bees[3] [10,11], etc.), and Distinction-making is often essential to the survival of the species.

When dolphins are born, their mother assigned them a name in the form of a "signature whistle." Later in life, dolphins utilize the Distinction and Relationship patterns to enhance their social behavior [12]. Dolphins learn the "names"— in the form of Distinguishable whistles—for the dolphins that they are close with and/or remember cooperating with in the past. Dolphins Distinguish and Relate to create cooperative teams, as is illustrated in the following excerpt from King et. al:
"...male bottlenose dolphins form a complex nested alliance hierarchy. At the first level, pairs or trios of unrelated males cooperate to herd individual females. Multiple first-order alliances cooperate in teams (second-order alliances) in the pursuit and defence of females, and multiple teams also work together (third-order alliances) [12]."
Scientists previously thought that complex team cooperation was unique to humans. However, the fact that dolphins distinguish amongst themselves, have unique identities, and relational social networks, reveals that other species engage in complex team cooperation and use underlying structural patterns of cognition.

If research confirms the innate and essential nature of distinction making - across the sensory inputs - it becomes relevant to explore associated activity within the brain as these things are occurring. For example, Badre, 2008 [13] researched the prefrontal cortex and working memory[4]. The memory function allows for active maintenance and manipulation of information over a brief interval in the service of a task. Of note is that working memory is considered to be domain-specific[5] in the brain, existing in specific areas of the brain depending on the stimuli. Badre's experiments tested for regional differences based on the working memory domain. He found that "when content-based distinctions are evident [in the brain/thinking processes], they are typically observed in caudal (near the posterior of the body) PFC [prefrontal cortex] structures." However, object or spatial distinctions have not yet been located and are considered to be controversial. While acknowledging this, Barde wrote, rostral (near the front of the body) PFC regions " … seem to be capable of maintaining information from multiple domains, such as object and spatial, in addition to integrated cross-domain information, such as an object in a particular location." Barde also noted that abstraction was found in the prefrontal cortex, and that studying

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[3] Worker honeybees have the ability to distinguish between other bees by the degrees of relatedness that they are to each other. They use this ability to preferentially aid the bees that are the most related to them. The researchers wanted to see if this principle applied to paper wasps as well. In short, the wasps either are not able to make those same familial distinctions, or they simply choose not to take them into consideration. Alternatively, they could use the distinction but without enough effectiveness to make it advantageous or noticeable (99).
[4] The memory function that allows for active maintenance and manipulation of information over a brief interval in the service of a task.
[5] In other words, it exists in specific areas of the brain depending on the stimuli.

abstraction could lead to a deeper understanding of the hierarchical structure of the brain. These findings increasingly show a potential neurological placement of where some Distinctions are made, and the potential for distinct areas of the brain being designated for different types of distinction-making is demonstrative of the existence of the Distinction pattern of mind.

Bukach et al. 2012 [14] attempted to teach a prosopagnosic participant how to recognize the previously mentioned greebles. Prosopagnosia is a condition in which the person does not have the ability to recognize faces compared to other types of objects. They wrote that, "...the expertise account of face-specificity hypothesizes that face recognition is a particular example of more domain-general mechanisms that potentially support expert-level within-category individuation across most visually homogeneous object categories." They mention that some studies done on neurotypical people have called into question the specificity of facial recognition, and it might not be faces that have a specific recognition point, but another aspect of that kind of Distinction. This participant's prosopagnosia developed after the anterior temporal lobe was damaged in a car accident. Along with this impaired participant, 5 age-matched male participants were tested as a control. The procedure for this experiment was replicated from Gautheir and Tarr 1997 [8] study mentioned above. The only difference was that they learned 30 of the greebles at the family level, but only learned 20 at the individual level. The impaired participant performed significantly worse than the control participants. He had to use alternative strategies such as figuring out the family that the greeble belonged to first, and then figuring out the individual identity. It took this participant extra trials to be able to meet the expert criteria than the controls did. What is interesting, however, is that the participant with prosopagnosia could be considered an "expert" at all. That indicates that even people who are impaired in their distinction-making have the ability to learn how to distinguish things more accurately and quickly.

Chemotaxis is a relatively well-known phenomenon discovered in 1881 by Theodor Wilhelm Engelmann [15] among others. Chemotaxis occurs when receptors on the bacterium distinguish between specific chemical compounds that prompt the bacterium to respond (or in the case of non living a chemotaxis-like process through energy gradients, etc.). There have been over 600 types of receptors identified, and some bacteria express over 130 simultaneously. Fundamentally, chemotaxis is a process used by single-celled organisms to move around and respond to their environment. Some can even hunt using chemotaxis [16,17]. A predatory microbe that uses chemotaxis to find its prey is doing this by picking up on a chemical secretion emitted by the prey. By measuring the concentration of the secretion, the predator can know how far away the prey is. From the prey's perspective, they can also distinguish between their environment and the chemical secretions coming off of the predator, resulting in a continuous cat and mouse game. May the best Distinguisher win. In summary, the general idea is that the predator and the prey both use a gradient-like sensing method where they use the concentration of the Distinguished chemical to search out their prey, or to escape.

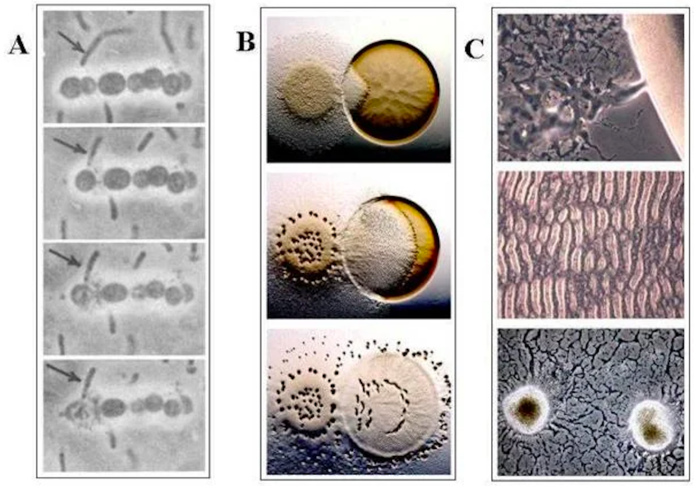


Figure 9: Types of predation by non-neural organisms. A: Colony invasion, B: Rippling wave structures, and C: Fruiting species.

This next study by Pradel et al 2007 [18] is a good example of chemotaxis in action. *Caenorhabditis elegans,* a nematode, is heavily present in soil. In its soil environment, there are nutrients it needs in order to survive, but there are also deadly pathogens it must avoid. In the lab, *C. elegans* systematically avoids the bacterium *Serratia marcescens*. This is shown in their experiment where they placed a nematode in a bacterial field and in a few hours the nematode had left that bacterial field. “By combining bacterial genetics and nematode genetics, we show that C. elegans specifically avoids certain strains of Serratia based on their production of the cyclic lipodepsipentapeptide serrawettin W2.”

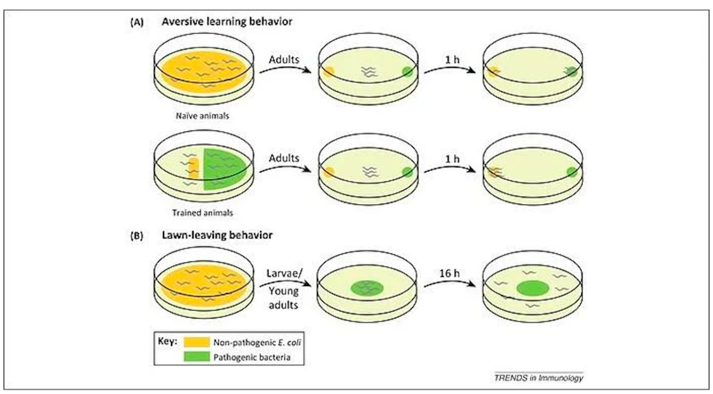


Figure 10: *Caenorhabditis elegans* avoids *Serratia marcescens* through chemosensation.

The nematodes are distinguishing this chemical from the rest of their environment and drawing the connection to the dangerous pathogen so that they can avoid it. “Recognizing and distinguishing among pathogenic bacteria represents a potentially valuable behavioral adaptation, which *C. elegans* demonstrates. It also demonstrates learning behavior, as it can alter its olfactory sensors after being exposed to a pathogen, trying to avoid the contact again.

In order to catch its prey, the Ogre-Faced Spider has a special move: the backwards strike. While resting on its web, the spider makes a net and expertly catches insects as they fly by, all in the dark. Stafstrom et al. (2020), found that, "by combining neurophysiological and behavioral experiments, spiders are shown to use low-frequency detection to capture flying prey[19]." In other words, the spiders use aural distinction-making to hunt. The Ogre-Faced Spider has a uniquely attuned auditory ability, and can distinguish the specific frequencies (150, 400, and 750 Hz) produced by the flapping wings of their prey. In the experiment, spiders reacted with a backwards strike when those frequencies were played. Interestingly, once the spider distinguished the correct frequency, they made a relationship between that frequency and incoming prey. In other words, their success as hunters depends on their ability to make distinctions and relationships.

In 2018, Rajalingham and DiCarlo [20] examined the inferotemporal[6] cortex and its role in visual processing and object Distinguishing. “Extensive research suggests that the inferior temporal (IT) population supports visual object recognition behavior… Moreover, inactivating different IT subregions resulted in different patterns of subtask deficits, predicted by each subregion’s neuronal object discriminability… Taken together, these results provide direct evidence that the IT cortex causally supports general core object recognition and that the underlying IT coding dimensions are topographically organized.” They conducted their research on object Distinction by “turning off” patches of the IT cortex using muscimol. They confirmed that areas/patches of the brain were devoted to face-recognition and also that the IT cortex is divided into areas that handle object recognition as well. When they turned off a patch, the subjects struggled with certain aspects of object recognition depending on the focus of the task. They wrote that, “individual neurons in the IT cortex are selective to complex visual features in images and exhibit remarkable tolerance to changes in viewing parameters.” The researchers made it clear that there was not a direct correlation between the task they struggled with and a corresponding area in the IT cortex. In other words, when a monkey struggled to Distinguish between cars (as a result of a turned off patch), that did not mean that there is a “car patch” in the IT cortex. They therefore stated that these findings hold for any kind of Distinction happening in the IT cortex, and they conclude that the IT cortex is an important area of the brain in which Distinctions are made. Finding a neurological placement in which Distinctions occur is significant, and this study provides evidence that the cognitive process of Distinction-making is not uniquely human, as the subjects in this study were monkeys. This drives the argument for the universality of the Distinction pattern of mind even further. In fact, once we are aware of the Distinctions we make, we begin to see examples of them all around us.

B: Real-world Examples of Distinction Making

B.1: Geographic Boundaries

Clark (1994) [21] looked at national boundaries and border zones and the impact those boundaries have on marketing strategy. Clark wrote that national boundaries are essential to international marketing, but are rarely discussed in literature. The boundaries are complex systems, and one fault at these borders can have significant repercussions. Borders dominate and shape economic behavior, which in turn affects a multitude of factors internationally. This article is a good example of the powerful impact

[6] The cerebral cortex on the inferior convexity of the temporal lobe in primates including humans. It is crucial for visual object recognition.

Distinction-making can have on real world issues. Drawing a boundary to Distinguish between two countries has an incredible impact on potentially millions of people. Not just the people directly next to the border, but also the people nearby, or that have a diplomatic relationship with the area of land being Distinguished. Many of the current boundaries we have in today's world were drawn without thought, or at the very least without a consideration of all the potential impacts and unintended consequences there could've been on the general population. How does one decide to make a Distinction like that? If you think about it, it's completely arbitrary. It's not a real Distinction; it's been completely manufactured by humans. The fact that an essentially meaningless line across a piece of land can have such a monumental impact speaks worlds about the strength and significance the act of Distinction-making can have on many domains, economic, political, social, etc..

B.2: Footwear

Dale Coye (1986) [22] explored the Distinction between the term "sneakers" and the term "tennis shoes." He was curious that in dictionaries, the two terms were related to each other (under the entry for sneakers, the dictionary said that they were also called tennis shoes.) So he gave 110 participants who had lived in the same town since the age of 5 or younger, a survey which asked them: "What do you call the things I'm wearing on my feet?" He was wearing regular white gym shoes. The participants listed any synonymous terms and about whether sneakers and tennis shoes were the same thing. People from the Northeast (47 participants) exclusively called the shoes "sneakers" and did not view "tennis shoes" as a synonym. The other 54 participants answered "tennis shoes" with only 9 stating that "sneakers" could be synonymous with that term. Coye discovered that the Distinct terms followed a geographic boundary, specifically the Northeast including Washington D.C. used the term "sneakers", while the rest of the U.S. used the term "tennis shoes." Thus, Distinctions are all around us - in terms we commonly use everyday without thought. When Coye looked at just one of these terms, he discovered a fascinating correlation with geographical boundaries. This holds true for all kinds of Distinctions, including linguistic ones.

B.3: Language

Another example is provided by Powers, Cabrera, and Cabrera 2016 [23], who explored the Distinction between the terms "Nerd" and "Geek" based on an analysis by Burrsettles in a blog post on Slack. The two terms originated from different places and root words, but they seem to be used interchangeably in normal conversation. Yet, when pressed, it was acknowledged that they are in fact Distinct terms. We find that context is essential when assessing the meaning of a word. This idea works in tandem with the Distinction rule, as the word becomes the identity, and the context becomes the other. The authors examined articles that attempted to articulate the Distinction between the two words, and found that by analyzing what parts Distinguished the terms from one another, they could arrive at the whole Distinction. For example, collections are "geeky", while academic fields are "nerdy." Analyses like these eventually led to the conclusion that, "Geeks are fans, and fans collect stuff; nerds are practitioners, and practitioners play with ideas (page 4). " This is another example of a linguistic Distinction. Awareness or metacognition about the Distinctions one makes can be incredibly helpful and impactful in policy, economics, science and more. Challenging the Distinctions made by others and one makes for themselves can provide richer analysis and deeper understanding of anything.

C: Distinctions have an identity↔other structure.

The underlying or elemental structure of the Distinctions PoM can be explained as "Distinctions are defined as an identity co-implying an other" or, D= i ↔ o. Numerous research studies illustrate these simple but sublime structural elements of thought.

C.1: Figure-Ground

Peterson and Skow-Grant 2003 [24] discussed how memory and learning work with figure-ground perception. Figure-ground assignment occurs when, "two regions share a common border." It is typical for humans to think that one region is perceived as being shaped by the border (or identifying the figure), while the other region is perceived as shapeless, and typically continues behind the figure as the background (this is the "other"). An example of this is shown in Figure 9.

Figure 11: Image depicting stimuli used in figure-ground assessment studies.

They found that in order to access memories about the figure-ground assignments, the prompt had to be the figure, not the ground. Using Gestalt principles, they reasoned that in order to be able to perform the process of memory matching, that prior, innate organization was necessary. Gestalt psychologists say that, "figure assignment is determined by any of a number of ''configural'' cues that can operate without accessing memory." Border assignment is incredibly helpful for the process of visual Gestalt grouping. This includes past experience with borders. Perterson and Skow-Grant write that, "a single past experience with a border is sufficient to establish a memory that is accessed the next time the border is encountered suggests that memories of object structure are remarkably plastic." They hypothesized that exploring the nature of border assignment (i.e., identity-other Distinctions) will further the research in this area. Forming Distinctions using borders is shown in this paper to be a surprisingly quick and fundamental tool for recalling memories associated with the figure formed using the border. Border assignment of visual stimuli is something humans (and other species) are doing every single day, all day long. This act of visually Distinguishing through boundary formation is fundamental to the brain and its processing of information into meaningful concepts.

Abdullah et al. [25] set out to measure the total amount of matter in the universe. They determined that 31% of the universe is made up of matter, while the other 69% consists of dark energy. Their

Distinction-making between matter and dark energy lead to a greater understanding of our universe. In fact, using the identity-other rule, we can even say that most of our universe is not matter, or an "other" to matter. In order to measure this, they used a part-whole Systems mentality, where they measured the mass and number of known galaxy clusters, and used numerical predictions to extrapolate to the whole universe showing the utility of both the Distinction and Systems rule to answer complex questions that have huge implications.

Picione and Valsiner, 2017 [26] explored narrative processes and verbal expression of one's experiences. They observed the nature of Distinction-making in speech and the establishment of borders in language. They offer that if a border could be viewed abstractly, it would be useful in working with ideas such as the self vs "non-self", and things like space and time. Examples of borders are shown below in Figure 10.

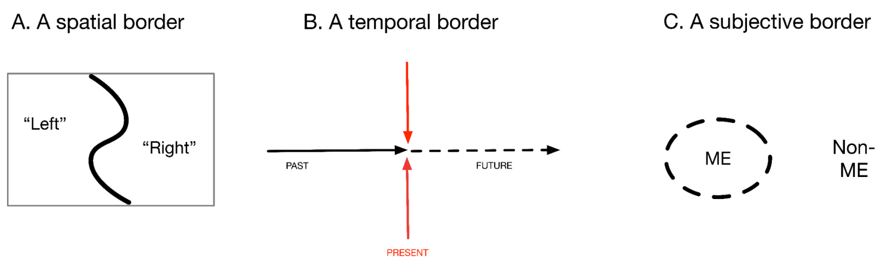


Figure 12: Examples of borders from Picione and Valsiner, 2017.

They also noted that borders have several functions which are, "to create a framework of sense, to diversify subjects and objects and to differentiate identities and positionings." They viewed borders as a tool to help people Distinctions that can become difficult for people to understand, particularly the ones that help them understand themselves. Identity-other Distinctions, it seems, are as relevant to concept formation, as they are to a simple shape, the meaning of a word, personal identity (self and other), psychosocial phenomena such as us and them, the creation of an identity marketing campaign for an entire corporation, or the identity that defines the patriotism within any country. Therefore, the knowledge and awareness gained through explicating one's identity-other Distinctions is NOT infinitesimal.

The self and other within Distinction making was also explored by Glanville (1990) [27] when he stated that a Distinction has to create itself. In other words, a Distinction IS an Identity. However, in order to exist, a Distinction also requires an other and a "transfer distinction." Meaning that in order for a Distinction to be valid, the other is a prominent part of the creation of the Distinction. This allows the Distinction to, "generate the purpose of the distinction as becoming, of, by and for itself." Although Glanville is right that the identity and other are necessary elements of any Distinction, and that there are clear benefits to being metacognitive about the dual-structure of any Distinction, *it is typical that more people make Distinctions while being unaware of this dual structure*. It is more often than not the case that the identity is explicit while the other is implicit (often with the intended or unintended consequence of marginalization).

This notion of identity and other was expanded to principles within organizational change efforts by Durand and Calori (2006) [28]. They explored the "sameness principle" and the "otherness principle" within organizational change. The Sameness principle is defined by the assumption that certain significant traits and characteristics of an organization remain during times of change for organizations. This principle has limitations, many of which are due to the lack of an "other." Even when the concept of an other is used, it's used as "another me." This is not allowing the thinker to get at the depth of what a true "other" can do. By framing the other using themselves as the point of view, they are just turning the other into another identity. This is not nearly as productive as an actual other to solving problems.

As a result, Durand and Calori introduced the otherness principle, defined as "what derives from the encounter with others and induces changes in an entity." Working with the concept of an "other" is significant for organizations, as not recognizing the other in your organization can lead to marginalization of people and ideas. This is why Durand and Calori concluded that the relationship between sameness and otherness is absolutely essential to the functioning of an organization. Without both principles working in tandem, they warn that there will always be limitations in the pursuit of organizational change.

C.2: Distinctions are shaped by the Other

Originally in Titchener, E.B. (1902), the Ebbinghaus illusion or "Titchener circles" is an optical illusion in which the perceived size of a circle changes relative to the size and proximity of the other circles surrounding it. *This means that the identity of the center circle is not only dependent on the characteristics of the central circle itself, but is intimately entwined with the other circles that surround it.*

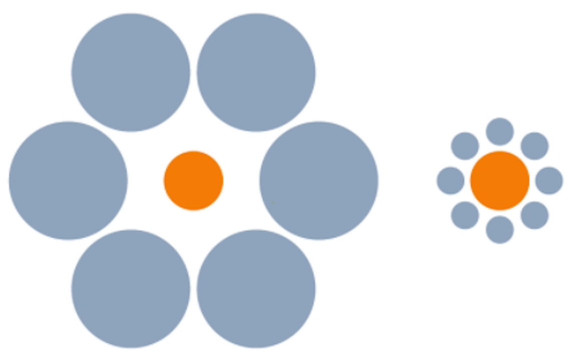


Figure 13: The two orange dots are actually the same size, but their context makes them look like they are different sizes.

Much like the circles, text and context have a similar relationship, as the meaning of a word or phrase is dependent on its context (or surrounding text). In other words, text gets its meaning internally from how it is defined (in a dictionary, for example) but also externally from its context. Yet, this context is not an amorphous cloud of meaning generating ether. The context itself is just more text. This can be seen in the imaginary text passages below. In this example, blue is the text being defined (i.e., the *identity*) and the yellow is the contextualizing text (i.e., the *other*). Note that the text in Passage B is merely part of the context in Passage A and vice versa (shown in green). In the second row of Table 2 you see an specific example using a homonym "rose" which can have different meanings depending on its context.

Passage A	Passage B

Text text texty text textual text text texty text text text. Text text texty text textual text text texty text text text. Text text texty text textual text text texty text text text.	Text text texty text textual text text texty text text text. Text text texty text textual text text texty text text text. Text text texty text textual text text texty text text text.
During a stressful time for the country, it would be good if the president rose to the occasion and showed some class.	During a stressful time for the country, it would be good for the president to show some class and place a rose at the site of the travesty.

Table 2. Example of identity and other in textual context.

Whether the identity is visual, linguistic, even self-identity or otherwise, a thing gets its identity not merely from itself or its existential qualities, but also from its relationship to others. We are reminded of the Zulu greeting, "Sawubona" which means "I see you" and the response "Ngikhona" which means "I am here." As always when translating from one language to another, crucial subtleties are lost. Inherent in the Zulu greeting and grateful response is the sense that until you saw me, I didn't exist. By recognizing me, you brought me into existence. A Zulu folk saying clarifies this, "Umuntu ngumuntu ngabantu," meaning "A person is a person because of other people." This reinforces the notion that identity and other mutually define one another. Additionally, the i/o structure of Distinctions exists across all of our sensory inputs in which we receive information: visually, aurally, linguistically, orally, and olfactorally. And while we know that Distinctions are made across all of our senses, the extent to which we are aware of the distinctions we make is equally relevant to explore. In other words, it is simply not enough to make distinctions in numerous ways, it also matters whether or not we are aware that we are making them.

D: Metacognitive Awareness of D(i ↔ o) Structure Matters

One's awareness of a thought process such as distinguishing one or more ideas rests on articulating a boundary between what is in and what's out.

Gillette (1925) [29] explains that the boundaries of a scientific field come from the boundaries of the phenomena under investigation. The boundaries of the phenomena also have to be defined by and decided on by people. Thus, there cannot be "clear-cut divisions" between and among the scientific fields, as people in each field cannot know exactly where the boundaries of their phenomena are, which isn't the case in reality. Those boundaries set by investigators in a field are then deemed to be "artificial." Recognizing and acknowledging the artificialness of the boundaries that we encounter everyday not only helps us to better understand academic fields, but it also moves us a step closer to understanding the real world.

Gillette further offers that social boundaries are established by both a person's conceptions of society and what society is, and that, "Society is association." This is another example of how prolific boundaries are in everyday life. So not only does society and sociability come about from Distinctions, but they are also heavily dependent on the increased interrelatedness of the elements "inside" relative to the interrelatedness of the elements "outside" of such boundaries.

Tajfel and Wilkes (1963) [30] found that classification[7] has an increased effect on the behavior of judgement, when the experience is repeated throughout the experimental session. The purpose of their experiment was to examine the effect classification had on quantitative judgements. This was accomplished through judging the length of a collection of lines, so that the judgement (in this case, length) would be simple. After presenting the lines one by one in a sequential order, their results showed that when classification is imposed on participants, the judgments people made were altered. They postulated that this could be due to the repeated and frequent experience of the same class of stimuli, which could then strengthen the association to it. This includes an increase in both the subjective difference between classes, and the subjective similarities among classes of stimuli. This pattern is exemplified by stereotyping—when humans tend to highlight the differences of the other, and the similarities of the group they identify with. The more experience a person has with one class of stimuli, the more judgemental they are towards other classes.

In 1982, Christine Davies [31] explored the relationship between sexual taboos and social boundaries. She found that the strong taboos in Western culture against things like homosexuality and beastiality were attempts to maintain and cultivate ethnic, religious, and institutional boundaries. She notes that these taboos cannot be of a biological or psychological origin, because other societies and species do not consider those behaviors to be taboo or, at the very least, have much weaker taboos in place. Davies writes that the origin of these social boundaries/taboos comes from either religious or military leaders. In order to maintain hierarchical control, they create a rigid, Distinctive identity for their followers to uphold. Davies also found that when an organization or leader tried to strengthen their group's boundaries, they began by regulating or controlling sexual behavior. This regulation creates an "other" for the majority to view as an enemy. In the example of homosexuality, the Old Testament clearly states that if a man sleeps with a man like he would with a woman, he is to be killed. This purposely marginalizes homosexuals, and creates a framework for an identity that the Jewish people (in this case) followed. This implies that the creation and maintenance of identity-other Distinctions can have a massive impact on people's lives, leading to discriminatory behaviors and policies.

Langer et. al. 1985 [32] wanted to understand the "mindfulness" (aka distinction-making) about groups of people by examining the psychological borders that structure thought through discussions of past and future, inside and outside, and self and other [26]. Experiments conducted with 47 sixth graders, demonstrated that teaching children to be "mindful," or to be aware of the Distinctions they were making, had a benefit regardless of the content of the lesson they were being taught. He did this through 40 minute sessions in class on mindfulness over 5 days. The students were shown slides either of "normal" people, or of handicapped people (handicaps included confinement to a wheelchair, blindness, deafness, and having only one arm). Which slides students were shown was randomly assigned. The students were then given booklets with questions designed to invoke either high or low levels of distinction making. There were four sets of questions: Set 1 consisted of professional skills questions; Set 2 of situational skill questions; Set 3 of explanations for events questions; and Set 4 of role-flexibility questions. A professional skills question (set 1) was asked each day; for this question the subjects were shown a photo of a person doing a job (ex: newscaster) who was either able-bodied or handicapped.

[7] Similar to categorization involves Perspective to frame under what conditions the item belongs to class, Relationships between items in the class, Part-whole Systematizing in order to group the class, and Distinction-making at the boundary of the class.

The high-mindfulness group was asked to list 4 reasons why a person would be good at their job, and 4 reasons why they wouldn't be, while the low-mindfulness group was asked to find only 1 reason. For Set 2, subjects were presented with a problem (person in a wheelchair and driving a car) and they were asked either "how" it might be solved (high-mindfulness group), or whether it "can" be solved (low-mindfulness group). Set 3 involved looking at an image and providing an explanation for what was happening (multiple for high-mindfulness and single for low-mindfulness). "In the fourth and final set of questions, asked on the last two days, we asked the high-mindfulness groups to consider several aspects of one role, whereas the low- mindfulness groups were asked to consider only one." And on day five, they began testing whether the children would choose to avoid a handicapped person. They were first shown a picture of three children and asked if they wanted to go on a picnic with one of the children. They were then shown a picture of three children, one of whom was handicapped, and asked if they wanted to go on a picnic with the handicapped child.

The results were that, "The most mindful group ("deviant" slides/mindfulness treatment) showed the least avoidance." Analysis of how the students responded to the slides, showed that the 12 students who were given high mindfulness training who were also shown handicapped slides chose the "right" (not biased) answer 92% of the time. The 12 students who were not shown handicapped slides but were given high mindfulness training got the right answer 33% of the time. For the students who were given low mindfulness training, the 10 shown the handicapped slides got the right answer 60% of the time, and the 11 that were shown the non-handicapped slides got the right answer 64% of the time.

In the discussion, the authors assert that, "mindfulness training was of some benefit to subjects regardless of the particular content of that training. The results suggest that one may decrease inappropriate discrimination by increasing mindfulness." They went on to suggest that teaching mindfulness was a way to reduce discrimination, because it helps people make more Distinctions about others. This also holds true not just for distinction making about other people, but also for making distinctions about other ideas. Langer's research illustrates both that the identity-other Distinctions one makes can lead to long-term marginalization of the "other" and also that awareness of the identity-other structure of Distinctions can dampen our marginalizing tendencies.

Perdue et al 1990 [33] explored the elements of Identity-Other Distinctions based on intergroup relations and how the phrases "us" and "them" affected an individual's identity within groups. They tested 23 undergraduate students, who completed 108 trials on a computer based trial. They were shown sets of seemingly random strings of letters in which each string was paired with either an in-group pronoun or an out-group pronoun. Additionally, one part of the string had a "nonsense syllable (xeh. yof, laj, giw, wuh, or qug)" and the other part was either the in-group (we, us, or ours) or out-group pronoun (they, them, or theirs). In contrast, the control group was given one pronoun of: he, she, his, hers, me, you, mine, or yours. The students were led to believe that they were participating in an experiment to test their verbal skills, and as were asked to, "indicate as quickly as possible which word of the presented pair was a real word." At the end of the 108 trials, they were shown the six nonsense words and asked to rate them as either "pleasant" or "unpleasant." Their results showed that, "The perceived relative pleasantness of the target nonsense syllables proved to be significantly determined by the pronouns with which they had been associated..." Using a least significant difference method, the nonsense syllables paired with an in-group pronoun were rated to be more pleasant than those paired with an out-group pronoun. "In general, in-group-designating pronouns appeared to possess strongly positive evaluative and affective associations as gauged against a set of control nonsense syllables, whereas out-group-designating words were relatively less likely to elicit such positive responses.” Their findings suggest that in-group and out-group terms (such as we, they, us, them) can subtly shape responses toward others and other groups. They further suggest that *ingroup bias is a more powerful bias than racial biases.* Gaining awareness of the way we assign identity and other distinctions therefore affects one’s behavior; and mitigates this bias.

Let’s look at these ideas in a real-world context. After the September 11th attacks, Leudar et al 2004 [34] reviewed the speeches made immediately afterwards by President George W. Bush, British Prime Minister Tony Blair, and Al Qaeda leader Osama Bin Laden. They analyzed the language and content of those speeches that showed that each leader quickly made “us” vs “them” Distinctions, to justify violent actions against the “other” group. For example, the first five lines of US President George W. Bush’s statement after the 9/11 terrorist attacks make some critical distinctions:

(1) Bush statement 11/9/01

THE PRESIDENT: Good evening. Today, our fellow citizens, our way of life, our very freedom came under attack in a series of deliberate and deadly terrorist acts. The victims were in airplanes, or in their offices; secretaries, businessmen and women, military and federal workers; moms and dads, friends and neighbors. Thousands of lives were suddenly ended by evil, despicable acts of terror.

Figure 14: First 5 lines of President Bush’s speech to the nation.

President Bush uses the pronoun “our” in his first sentence, which implies that there must also be a “them” to his “our.” For every identity implies an *other*. Furthermore, in his use of “our”, he refers to the victims he lists, and to the nation as a whole. His use of “our way of life” and “our very freedom” resonate with ideals that are important to Americans, that make up large portions of their identity. Leuder et al argue that President Bush’s implicit and explicit characterization of the “other” makes it possible to expand the construct of the *enemy* beyond merely *terrorists* to include more parts and a wider range of other things, such as people and ways of living.

They then related the 9/11 example to the concept of member categorization and the three ways to construct and change member categories. The first is through “changing the predicates normatively bound to a category (personal characteristics, dispositions to act in a particular way etc.)” The second is “by respecifying the incumbency of the category.” And the third is through “changing a collection into which the category is allocated.” They stressed that these three processes are not independent of each other, and doing one may require the adjustment of the others. Finally, they found that the creation of membership categories was related to action, and in concert with a particular purpose. Just as a lack of awareness (metacognition) about the distinctions one makes can lead to unintentional marginalization of groups, the act of distinction making can also be used to purposefully marginalize others.This can happen subtly and explicitly. Creating marginalization can come from an awareness of one’s own Distinction-making or that of others. It requires one to take a Perspective other than their own to determine the in and out group distinction for one’s self or for others. This is the basis for manipulation, agendas, and conflict. Thus, the elemental patterns of Distinctions (identity-other) are powerful on their own, but as this paper demonstrates, combining the patterns together can be essential to ensuring that one doesn't use their newfound metacognition for manipulating others or themselves.

This type of manipulation typically starts with a stated boundary between insiders and outsiders, us and them, etc. Young 2005 [35] articulated the act of distinguishing ideas by defining the two terms "insiders" and "outsiders." "Insiders" (or Emic) was said to be linked to the concept of the self, or and more specifically is, "the situation of one's self within a group, experience and/or community." Interestingly, she also noted that the act of being an insider also included the ability to understand how the self is perceived by others. The "outsider" was said to be related to the concept of the other, and was explicitly defined as, "the situation of one's self without a group, experience and/or community." She wrote that one can become an outsider based on several possible criteria from a multitude of factors including, race, gender, ethnicity, social class, and even personal domains. Insider and outsider concepts have greatly influenced a process called Participatory Action Research (PAR), which was designed to lift up and give a voice to oppressed or disadvantaged peoples rather than serve to keep helping the people with more social, financial, and political power. The use of insider and outsider perspectives in the PAR process allows for better (more inclusive) research and conclusions, problem solving, and social change.

Another significant part of Young's paper focused on identity, using herself as an example, she offered that a person's identity has to be created, and is created through their person's insider/outsider placement in various aspects of their life. On top of that, there are infinite possible identities such that new identities can be "discovered" as more people in a society begin to identify themselves as something not previously thought of as an identity. Gender identities are an example of this phenomenon[8]. This is exemplified within the creation of labels and the addition of recognition of the person, thing or group that is **not** the identity. This often happens through either the creation of government programs, social movements, and general ideas of societal acceptance. Note also that identities change over time as perceptions and societal implications or consequences shift. They also change as the individual grows developmentally and chooses a new identity. Additionally, as the individual's context changes, their identity shifts. One can identify as one thing while at school and another while at home with their family. One's identity is influenced by how prevalent the "other" is in their context. Young offers that the current mental model about identity is that identities are rigid and stagnant, while the opposite is true. Identities are flexible, constantly changing, and adjusting due to a variety of factors. Most importantly, the implication of these ideas is that when one explicitly deals with identities (especially the hidden ones), the act of "othering" is greatly reduced. As more and more identities are accepted, people personalize all the "thems" that they had marginalized previously. This paper explicates the societal importance of awareness of our identity/other Distinctions, and also the effect of metacognition on one's identity and other Distinctions.

Midgley and Pinzon (2011) [36] explored the role of boundary critique and conflict, specifically in the context of conflict resolution and prevention. Their work demonstrated a need for people to explore their differences, and be supported in that exploration. Their work highlights the need for Perspectives within boundary critique. This is because "different interpretations of a common concern arise…" between people and cause conflict. Through the framing/reframing of ideas and boundaries, conflict can not only

[8]Previously, here were 5 medically driven gender identities male, female, hermaphrodite, female pseudohermaphrodites (individuals who have ovaries and some male genitalia but lack testes), and male pseudohermaphrodites (individuals who have testes and some female genitalia but lack ovaries), but now there are 64 accepted variations of gender.

be resolved, but potentially prevented. They write that, “in particular, if parties who frame a phenomenon differently can be supported in identifying their core and peripheral concerns, stigmatisation can be short-circuited through the promotion of better mutual understanding.” This paper demonstrates the function of identity-other Distinctions related to conflict and conflict resolution. In other words, Midgley and Pinzon suggest that when one is aware of the way they are assigning “otherness” to people, they may try to do it less, which leads to more productive conflict resolution, and, in general, a society that gets along easier.

Bentley et al 2017 [37] examined the effect inclusion and exclusion had on both the self, and one’s retention of information about the self and the other. He conducted an experiment with 169 first year psychology students on the effect inclusion and exclusion had on the retention of information about oneself and others. They used a computer-based experiment in which participants completed a questionnaire about themselves, and then played a computer game with another person. Before they played they viewed the other player’s (fake) questionnaire results. As a result, participants classified their opposing player as either matched or opposite to their own results. This assigned either an ingroup or an outgroup status to the subject pairs. They then tested each subject's memory of their opponent’s questionnaire results. Between-subjects, one-way, ANOVA test, showed significant effect on the “psychological need satisfaction[9].” In the inclusion condition, reported need satisfaction was highest among all other conditions. In summary, they found that when the subject was excluded from the ingroup, they retained (in a memory retention test about the experiment) significantly more information related to themselves than they did about their opponent. However, when included in the ingroup, the participant remembered (within an appropriate margin of error) as much information about the other as they did themselves. The authors concluded that it was possible that inclusion added to their self identity, and that the other also became the same as a part of the self when the two are perceived to be in the same group (ingroup). Identity and other, or inside and outside classification, are important underlying factors to our perceptions of ourselves and of others.

3. Part-Whole Systems

Systematizing (S) is the act of organizing things or ideas into parts and wholes. In other words, explicitly grouping a concept into a whole made up of parts or breaking something down into its constituent parts. This reinforces the idea that every whole has parts while simultaneously being part of a larger whole. Systematization of things or ideas is evident in both monkeys and infants as early as three months of age. Similar experiments with adults show the varied and sophisticated ways systems-part-whole is used to understand concepts across the lifespan.

A review of peer-reviewed journals across disciplines indicates:

1. the existence of Systems (i.e., part-whole groupings);
2. the act of Systematizing (i.e., splitting into parts and/or lumping of parts into wholes);

[9] With a p-value of $p<0.001$. Between-subjects, one-way, ANOVA test, showed they found that there was a significant effect on the “psychological need satisfaction” through social context manipulation.

3. that the relationship between "part" and "whole" (i.e., S($p \leftrightarrow w$)) is elemental to (1) and (2) above; and,
4. that the human tendency with Systematization (grouping of parts and wholes) is marked by "lock-in" where part-whole groupings that are dynamic, evolving, organic, or perspectival erroneously end up becoming static, "accepted," categories, and hierarchies.
5. In summary, it shows that items 1-4 are fundamental "patterns of mind" agnostic to content area (across disciplines) and throughout the lifespan of humans. Yet, where Systematization is concerned, the difference between thinking (ie., cognition) and systems thinking (i.e., systematic metacognition) is not in the S($p \leftrightarrow w$) structure of cognition itself, but in the willful and purposeful attempt to see (i.e., be aware of) the S($p \leftrightarrow w$) structure that is at work when thinking.

A: Systems Exist in Mind and Nature

Like Distinctions, Systems exist in both Mind and Nature. They are both real things and conceptual things. And, Systematizing is a universal cognitive structure. We cannot think a thought, without also making a part-whole System.

Nobel Laureate, Herbert Simon [38] explains, "Empirically a large proportion of the complex systems we observe in nature exhibit hierarchic structure. On theoretical grounds we could expect complex systems to be hierarchies in a world in which complexity had to evolve from simplicity." Complexity is born of simple rules and the collective dynamics of interactions among agents. The emergent properties of a system yield system-scale boundaries which, when nested, lead to hierarchical organization. At its core, hierarchy of any kind across physical, chemical, biological, psychological, and sociological organizations, is simply a nested part-whole structure. Although, as Simon explains, this hierarchy is empirically verifiable, it is so basal to the structure of nature itself that it is nearly an *a priori* principle. Part-whole Systems exist in nature. But they also exist in our mind. Sometimes our conceptual hierarchies appear to align with nature (as the basic disciplines of physics, chemistry, biology, psychology, ecology, and sociology seem to confirm) and sometimes they do not (as numerous flawed taxonomies such as Bloom's and Maslow's and the Species Concept have shown). In any case, the structure of Part-Whole Systems are not only found in Nature but also in the Mind.

Revisiting Leonid Euler and the ubiquity of networks in mind and nature, it is easy to see that nodes in a network are part and whole. Any network (in mind or in nature) is therefore a part-whole System. But more importantly, DSRP Theory tells us that any one of those nodes (indeed any one of those relationships (i.e., "edges") has the potential to be a system and usually is. Take a simple example of a social network or an ecological network. Each of the nodes in that network are complex part-whole Systems themselves. Not only is the network itself a part-whole System, one can imagine that inside each and every node, there exists a network of lesser, equal, or greater complexity - comprised of parts and wholes.

Humans naturally systematize things by breaking them down into parts and wholes automatically, which often leads to the creation of "groupings" or what we often erroneously call "categories." However, categories require something else: a *Perspective*.

Anderson (1991) [39] analyzed the adaptive nature of human categorization. In framing a cognitive problem, Anderson noted that categorization of the elements of the problem is an essential step towards building a complete frame. He listed three origin points of category formation: linguistic, feature overlap, similar function. These three origin points (alone or together) make up the *perspective* that *frames* and subsequently *forms the* category.

When categorizing, *linguistics* are derived from the label of the object. For example, all of the things below are grouped because they start with the letter O, Ostrich, Orange, Octopus, Octagon, etc.

Figure 15: Example of the linguistic categorization origin point.

Feature overlap occurs when we identify similar physical or conceptual features in a group of objects. As shown below, these objects are grouped into a category as "all red objects." It might be helpful to think of categories using a metaphor like a bouncer at a night club. When we form categories, we create a frame (using a perspective) which decides what objects get into the club and which ones don't. In the case above, you only get into the club if you start with the letter “O.” The bouncer is the perspective that creates the category.

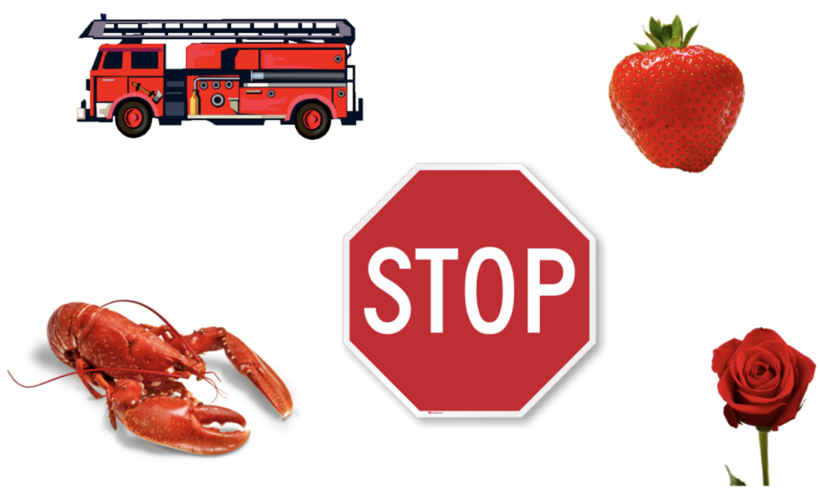


Figure 16: Example of the feature overlap categorization origin point.

Finally, Anderson identifies categories based on *similar function* by simply grouping objects that function similarly, as shown by the musical instruments below.

Figure 17: Example of the similar function categorization origin point.

The origin of categorization does not have to be one of these, but can be all three of them. He goes on to conclude that, “categorization behavior can be predicted from the structure of the environment at least as well as it can from the structure of the mind.” In other words, the mind naturally categorizes the world around it, and the Systems pattern is therefore embedded into the very nature of thought itself. Understanding part-whole systems will give insight into this fundamental aspect of our cognition.

Note also that DSRP (in this case specifically S and P) shows us that Anderson's three originating points for a category (feature overlap, linguistics, and similar function) are somewhat arbitrary and not complete, as ***absolutely anything*** could be used as the framing perspective that leads to a category forming, such as: how objects make you feel, color (not a feature of object but an interaction effect), random assignment, sounds you might associate with the object(s), etc.

While Anderson offered that categorization can be predicted from the external environment, Pellegrino, 2001 [40] implied that categorization is a shortcut to deal with complex environments or concepts. Pellegrino reported on experiments in which morphs of dogs and cats were made, so that each image was a certain percentage of a cat and a dog, but the images were never 100% dog or cat. The images were shown to monkeys, and the monkeys had a surprisingly high success rate of categorization (90%) even when the image was close to being a 50-50 split. For example, if the split was 60% dog and 40% cat, the monkey would correctly categorize the image as dog 90% of the time. In addition, they found that the neurons fired differently when the split was 60/40 dog to cat, then when it was 60/40 cat to dog.

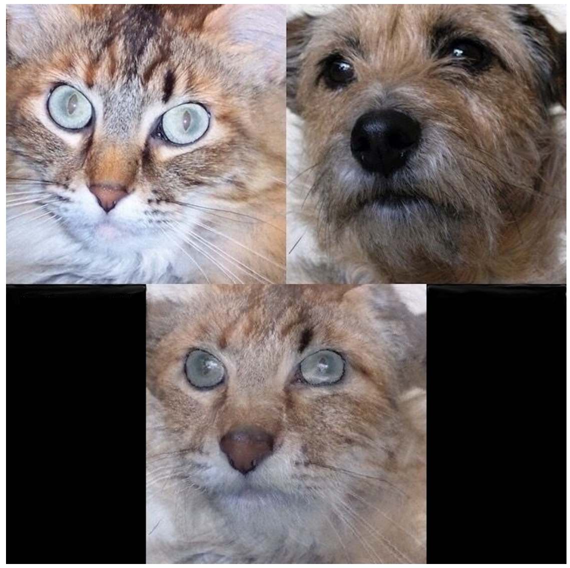


Figure 18: Example of Cat/Dog Morph.

They observed that "categorical knowledge is explicitly represented in the firing rates of prefrontal neurons." He also found that neurons responded differently to stimuli that were morphologically similar (i.e., dog and cat) but rested on opposite sides on the spectrum than it did to stimuli that were morphologically different (i.e., dog and shark). This led to further exploration of where in the brain the act of categorization - or organizing into parts and whole systems occurs.

Muehlhuas et. al. 2014 [41] used fMRI studies to demonstrate the neural basis for part-whole and other categorical relationships that could potentially be distinguished. In their experiment, 22 healthy adults were tested by analyzing picture/word combinations (see Figure 13) in three categories "(1) 45 functionally related picture–word pairs, e.g., flute-note, (2) 51 part-whole related picture–word pairs, e.g., bike-handlebars, and (3) 96 unrelated picture–word pairs, e.g., bench-plug." In addition, all pictured objects were labelled with their names to ensure there was no "false-naming" occurring.

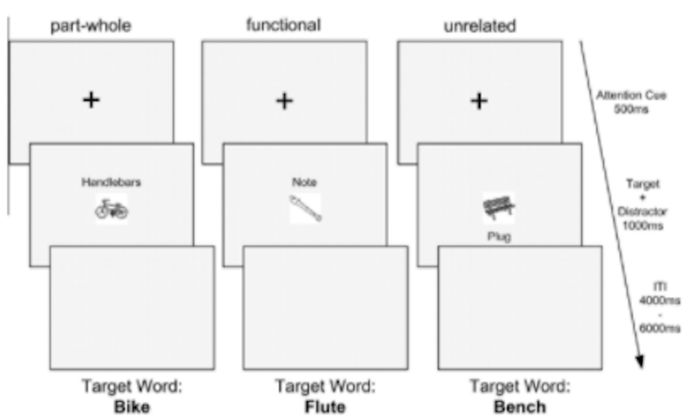


Figure 19: Example of the three stimulus groups used in the experiment.

As participants matched the word pairs their brains were analyzed with the fMRI machine. They did 192 trials of each of the three categories while in the fMRI. Analysis of average response time between and among the three types of relationships, found no significant difference among them. They wrote, "To test the hypothesis that fine-grained associations are organized by distinct features (intrinsic versus extrinsic) with characteristic neural activation patterns, t-contrasts[10] between functional and part-whole relations were conducted to identify the brain regions that are involved in the relative processing of part-whole versus functional associations." This did not lead to a conclusive result, however, when looking at the relationship between the functional tests to the part-whole tests, there was a small amount of activation in the location in the brain where scenes are encoded. When the pattern is reversed (part-whole tests to functional tests) they found activation patterns in the regions that are involved with perceptual details, but further research needs to be done; this is the first definitive evidence of part-whole Systems being structurally visible in the brain. Research into categorization explores common usage of the Systems part-whole pattern. This shows that humans and animals successfully categorize and make part-whole systems, and provides the scientific community an inkling into where the innate Systems pattern is located neurologically.

Montoro et. al. 2014 [42] wrote on the subconsciousness of grouping, specifically Gestalt grouping that offers that *the whole is more than the sum of its parts.* They did two experiments, the first one was on grouping by proximity. They took 38 undergraduate students and had them complete two tasks: a masked priming task and a prime visibility discrimination task. For the masked priming task, the students completed a "forced-choice reaction time" task. They were told that they would see target lines displayed on the screen, and that they would then have to indicate either the vertical or horizontal orientation by pressing one of two buttons as fast as possible but to avoid making mistakes. For the prime visibility discrimination task, the participants were told to pay attention to the prime stimulus that was displayed between two masks, and to perform a "forced-choice discrimination" task indicating the horizontal or vertical orientation of that stimulus. They asked the participants afterwards what patterns they had seen on the screen before the experiment began, and none of the participants said that they had seen any horizontal or vertical patterns. This means they weren't aware of the priming. However, the priming significantly influenced the speed and accuracy of their reaction time. However, in the forced grouping task, the analyzed results showed that the subjects weren't able to see the grouping patterns when they were masked.

For the second experiment, the focus was to test grouping by similarity. This experiment had 38 undergraduate students as the participants. "The stimuli and apparatus were identical to those of Experiment 1, with the sole exception that the Gestalt patterns consisted of a 6x6 array, forming rows or columns with elements of identical luminance." Otherwise, the procedure and design was identical. The second experiment also concluded that there was a significant effect of priming, and the subjects also were not aware of their priming. For the forced grouping task, their analysis was the same as the first experiment. When masked, priming is not noticed by the subjects. They concluded that their results demonstrated that there doesn't need to be an aspect of consciousness in order to perceptually group something. Overall, the article makes the point that there is an uncontrollable nature to Gestalt grouping. This is notable in its similarity to the four patterns of mind —DSRP—that are happening within every

[10] A type of statistical test.

thought one has, without their control. Note, the awareness of such patterns is of equal importance to their existence.

Savantism[11] is found more often in people with an autism spectrum condition than in people without it. In Baron-Cohen et al.'s [43] research, they explored what cognitive aspects of autistic people cause this phenomenon. Across people with an autism spectrum condition is the ability to have excellent attention to detail. Baron-Cohen et al. argue that this is born of their enhanced ability to Systematize. They also tend to have sensory hypersensitivity, which contributes to their ability to Systematize. Systematizing is about "recognizing repeating patterns" of the stimuli the person is interacting with/paying attention to. In their research, a *system* is defined as a thing that follows rules, and *systematizing* is the process of identifying those rules with the purpose of predicting how the system will behave. They recognize these main types of systems [43]:

- Social systems (i.e., a business or even a dance routine);
- Numerical systems (i.e., a calendar or a bus schedule);
- Collectible systems (i.e., making distinctions between rocks or wood);
- Mechanical systems (i.e., a window lock or video camera);
- Motoric systems (i.e., bouncing on trampoline or throwing a ball);
- Natural systems (i.e., weather patterns); and
- Abstract systems (i.e., musical notation or language syntax)

What is the evidence that autistic children systematize better? Children on the autism spectrum perform better on physics tests than neurotypical children. Even children aged 8-11 with Asperger's syndrome performed better than neurotypical teens. The Systems pattern is present and sometimes heightened in people who are not neurotypical. The brain does not have to function normally to perform the Systems pattern.

B: Systems have a Part-Whole Structure

The most common, simple definition of a system is, "a regularly interacting or interdependent group of items forming a unified whole[12]." Kurt Lewin's A Dynamic Theory of Personality (1935) [44] discusses many aspects of personality, one of the most relevant being the structure of the mind. He wrote, "The cause of the process *b* is not to be seen in its rigid coupling with the preceding independent event *a*. Rather, if *a* forms a dependent moment of a more comprehensive whole, it carries that whole with it. Thus, indeed, no chain-like coupling of member to member, but the connections of the parts in the whole, is regarded as the "cause" of the event." In other words, it is not enough to make distinctions and relationships between objects/concepts, but one also has to evaluate the concepts/objects as parts and wholes. This also suggests that relationships are made up of Part-Whole dynamics.

Mooney (1951) [45] took his observations as a former teacher on the "part-whole" problem and applied it to a neurological study that attempted to find where Part-Whole grouping occurred in the brain. Mooney was a teacher who throughout his career realized a significant problem in the norms of teaching. "Sooner

[11] Having a prodigious talent.
[12] Definition from https://www.merriam-webster.com/dictionary/system

or later, those who are responsible for teaching come face to face with the problem of parts versus wholes." Mooney wrote that every teacher has wondered whether to teach from Parts to Whole, or Whole to Parts. However, he had noticed issues with both of these strategies. If one teaches from the assumption that if you teach the Parts, then you assume that the students will understand the Whole, yet this isn't the case; there is a disconnect. A similar problem arises when you teach the Whole and assume that the students will know the Parts. He found Part-Whole to be an important conceptual tool for teaching, but it was used primarily in math and not in many other places. He did three "demonstrations," the first focused on "perception", the second on "language," and the third is on both "perception" and "language." The first demonstration is the most relevant to this review, and will be the one discussed.

The first demonstration was done using pin-points of light. A group of students (one at a time) were put ~20 feet from the "front of the room." They gave the students time to acclimate to their surroundings. Then they turned off the lights and had the students focus on a "light-tight" box in the front of the room. The only thing that can be seen from the box, is a very small pin-point of light. The light is turned on, and the students are asked to watch the pin-point of light. After about a minute of watching, the light would begin to appear to move. They saw that as the students saw the movement, they would sometimes move their heads to follow the light, even though the actual light itself has never moved. While this apparent movement continued, two additional lights were turned on, the perceived motion ceased, and then continued with all three lights moving in unison. They found that the movement of the single light was more impactful than the movement of the three lights together. When the overhead lights were turned back on, all apparent motion stopped.

This demonstration showed that in just the act of focusing on and following a pin-point of light, the brain/self has to do many things. In particular, this demonstration showed how essential relationships are to the dynamic of part/wholes. He writes that the very act of perception is creating relationships between parts of an environment/stimulus in order to get a conceptual grasp on the whole. Moony writes, "When a relation is accomplished, those things which had been taken as different are taken as included in a "one", whereupon the "one" is taken as assumption for further action, with attention turning elsewhere as an invitation to further relationships, at which time the things which had formerly been sensed as stable are then sensed as moveable. The greater the number of differences included within a relationship (or a system of relations), the greater the apparent stability of the field." The reason that people have to operate in relationships is that we don't have the environment living in our heads with us. In order to get to a semblance of the reality one exists in, one has to build relationships between the environment and the self. This is done in a couple ways, the one demonstrated here is perception.

He went on to write that part-whole concepts/tools don't have to only apply to math, as it is an important cognitive skill and could be used to help students learn in all subjects (he mentioned reading quite a few times). This article indicates that even in 1951, people were aware that part-whole didn't just apply to the things it came easy to, like mathematics. More importantly, it showed that the relationship between the Part and the Whole needs to be explicated if one is to give a complete conceptual understanding to their students.

Ackoff (1971) [46] explored organizing Systems concepts and ideas into its own System. He notes that part and whole are some of the key tools used to understand and evaluate systems across fields. The "systems approach" to solving complex problems, is to look at the whole, not each of the individual parts. The properties of the systems, Ackoff stated, comes from the relationships between a System and its parts. He notes that the way the parts of a System interact and behave with each other leads to the emerging properties of that System. He also said that "all systems are either variety- increasing or variety-decreasing relative to the behavior of its parts." The way parts of a system relate to one another, according to Ackoff, is through observation and communication. In his concluding remarks Ackoff said "Systems thinking, if anything, should be carried out systematically."

A review on categorization Solomon et. al. 1999 [47], began with the statement, "Concepts are the building blocks of thought. How concepts are formed, used, and updated are therefore, central questions in cognitive science." In the review, "concept" was defined as a "mental representation that is used to meet a variety of cognitive functions." Through their review, they realized that the study of concepts has primarily been done through the study of categorization. In their analysis, they realized that the conceptual functions interact and influence one another. In fact, some conceptual representations are often a compromise between conceptual functions. This is a shortcoming of categorization. They argue that:

> "...concepts cannot be understood sufficiently through the study of categorization, or any other function, in isolation, for two important reasons. First, concepts serve multiple functions which interact to affect conceptual structure and processing. Second, studying a single function in isolation encourages one to see cognitive processes that are particular to each function, but discourages the discovery of processes that are common to multiple functions. For these two reasons, we suggest that concepts should instead be studied in the context of a System of interrelated functions."

This analysis emphasizes the importance of seeing parts and wholes in the larger context of interrelatedness to better understand systems.

C: Metacognitive Awareness of S(p ↔ w) Structure Matters

The simultaneity of Distinctions (identities) acting as Systems (either wholes or parts) was examined by Tversky and Hemenway (1984) [48]. They studied objects, parts, and categories and discussed Gaul, who observed that when "describing or comprehending some body of knowledge or set of phenomena, we often begin by decomposing the thing to be understood into separate parts." They noted that this was done not just because smaller parts are easier to deal with conceptually, but also because each Part is an entity within itself, and needs to be dealt with as a distinct thing. They later wrote that, "our work has shown that one particular kind of information is more salient in the minds of people when they think about entities at the basic level, namely, information about parts."

The process of categorization is prevalent in human thought and research because of their utility evolutionarily. Categories are an adaptive tool easily applied to situations throughout time. Glushko et. al. 2008 [49], discussed the highly adaptive nature of categories. The evolutionary origins of categorization relate to the ever-changing world of technology, as technology and technological categorization (part-whole Systems) change and evolve, one's brain quickly adapts in concert. They write, "this illustrates a fundamentally important principle of human categorization mechanisms: as the context changes in which human categorization mechanisms operate, they produce new types of classification systems. When new technological tools become available, categorization mechanisms adapt quickly and new classification systems result. Rather than categorization being a fixed process, it evolves dynamically as situational constraints change." This quick ability to adapt to differing categorization systems implies that there are neurological structures built into our brain that make categorization easier for us. It also indicates that the categories we make are not merely static part-whole Systems or groupings, but are sensitively dependent on the perspective that is being used to organize content or phenomena into categories in the first place. In short, categories are structures born of several elements of thinking—part-whole Systems, Relationships, and Perspectives. Notably, once categories are formed, they also become boundaries/distinctions in and of themselves.

Liberman et. al. 2017 [50] argued that social categories help people navigate the increasingly complex social world around them. Through reasoning about predictable thoughts, actions, beliefs, and possible interactions with and among others are guided via the group membership that individual(s) assign to themselves. Thus, categorization within the social realm has some positive effects. They wrote, "forming conceptually-rich categories has obvious functional value – social categories organize our vast knowledge about human attributes and about the complex relationship networks that comprise human social life." In other words, people use information about group membership to infer whether they will share properties, and how people will interact. Thus, these conceptually-rich social categories emerge *before* the provision of verbal information can affect social knowledge, *suggesting that the ability to form social categories does not depend on explicit learning about the cultural or stereotypic content associated with different groups*. Further, the ability to use these categories to draw inferences about social structures likely drives social thinking and learning from early on.

The downside of those very same categories is the unintended consequences like bias, prejudice, stereotyping, and discrimination. Interestingly, social categorization requires the individual to place themselves into their desired group. Psychologists are careful to state that prejudice takes many forms, "social psychologists have long noted the distinction between explicit prejudice (negative affect towards an outgroup) and endorsement of stereotypes (cognitive representations of culturally held beliefs about a group)." Therefore the awareness of how one organizes thoughts into part/whole systems based on a particular perspective—is a useful way to increase awareness of one's biases. Awareness of DSRP maintains the positive aspects of categorization and increases awareness about the negative effects as well.

Fisher and Keil, 2018 [51] explicate that humans have a tendency to treat evidence as binary. As a result, their beliefs that formed from binary evidence are distorted because they have inaccurately weighed the evidence, based on the severity of statistical estimate. Importantly this bias influences "how people use data to make health, financial, and public-policy decisions." They highlight this pervasive binary bias as one of the largest dangers of categorization, especially when applied to the serious issues above. In one study 154 participants were randomly assigned to one of four groups (scientific reports, eyewitness testimonies, social judgments, or consumer reviews). They were then shown 5 statements about the relationships between and among the materials they had observed. The results of the study were, "that the binary bias has a stronger influence on the formation of beliefs and attitudes than the previously documented factors of order and salience." Binary thought tends to be damaging to both mental models and deep understanding of concepts and problems. They wrote, “the binary bias appears to be a pervasive aspect of cognition with extensive real-world implications.” In other words, the human tendency to categorize things in a binary manner can impede the formation of accurate mental models of phenomena (as the world exists in shades of gray - not black and white); see relationships (falsely) as only cause and effect (rather than webs of causality) and narrows our perspectives on things towards bivalency in lieu of multivalency. Thus, systems thinking (DSRP) shifts this paradigm away from the binary bias and towards a more spectrum-based thought process.

4. Action-Reaction Relationships

Relationships (R) refer to the act of relating things using action and reaction. In other words, explicitly working with concepts while being aware of the relationships, systems, and distinctions between them. Infants show evidence of relating as early as seven months of age, while experiments with adults show the varied and sophisticated ways relating occurs across the lifespan. A review of peer-reviewed journals across disciplines indicates:

1. The existence of Relationships (i.e., R as a noun/object);
2. The act of Relating between and among things (i.e., R as a verb/action);
3. That the relationship between “action” and “reaction” (i.e., R(a ↔r)) is elemental to (1) and (2) above; and,
4. That the human tendency is heavily weighted toward Di, Spw, and the relative absence of Relationships. Further, when relationships are identified they are often seen as linear causal rather than webs of causality. Finally, Relationships that are drawn are rarely identified (RDi) or Systematized (RDS).
5. Items 1-4 are fundamental “patterns of mind” agnostic to content area (across disciplines) and throughout the lifespan of humans. Yet, where Relationships are concerned, the difference between thinking (ie., cognition) and systems thinking (i.e., systematic metacognition) is not in the R(a ↔r) structure of cognition itself, but in the willful and purposeful attempt to see (i.e., be aware of) the R(a ↔r) structure that is at work when thinking.

A: Relationships Exist in Mind and Nature

Like Distinctions and Systems, Relationships exist in both Mind and Nature. They are real things and they are conceptual things and sometimes they are in alignment. And, drawing Relationships between and among ideas is a universal cognitive structure. We cannot think, without forming Relationships.

Let’s revisit Leonid Euler and the ubiquity of networks in both mind and nature. Previously we explained that Euler, in abstracting and thereby solving the Konigsberg problem—invented graph and network theory. His abstraction included two basic elements: nodes and “edges.” The edges in a network are the Relationships between nodes. Ergo, in all of the many networks and examples of network theory’s powerful utility as a tool across the physical, natural, and social sciences as well as commerce and industry, we see Relationships.

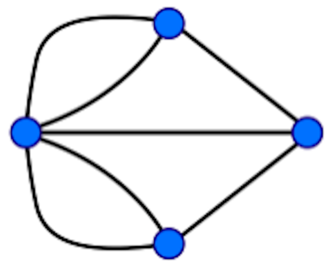


Figure 20: In networks, “edges” are Relationships.

While Euler (1735) [3] set forth the notion of systems composition of parts (nodes) and relationships (edges) researchers have explored the nature of relationships more fully.

In a review of *Cybernetics* (1948) by Norbert Wiener, John Weily, 1951 [52], raised many points of interest in his discussion of machines, and the underlying Systems that run them. Of particular interest was his discussion of a very important structural type relationship found within System: feedback loops. Weily recognized that feedback loops can become dangerous or impossible in machines, but they can be an essential tool/process of cognition. He writes that, “The concept of feedback is undoubtedly so important that the social no less than the natural scientist ought to be familiar with its denotation.” The structure of a feedback loop is a critical relationship that allows the System to react to its environment and potentially restructure itself in response. Ultimately, the feedback loop allows some Systems to regulate themselves, with the more obvious examples found within biological Systems.

Researchers later examined the process of making relationships in the mind. Clement and Falmagne, 1986 [53] studied the relationship between imagery, schema and comprehension of material. They conducted two experiments: the first examined respondent’s “performance on conditional reasoning problems” based on the relatedness of information and imagery presented to them in the experiment. Two rating tasks were developed—in the first— a sentence was read, and then rated on a scale of 1-5 relative to the ease with which participants could form a picture in their head that was related to the sentence. More specifically, “In a relatedness rating task, subjects rated conditional statements according to how easily or naturally they could conceive of a relation between the two actions described by the constituent clauses.” They were sure to mention that the Relations should be natural, and what came to mind first was what should be reported. After the rating (in which any stimuli that was rated zero was removed from the test) a conditional reasoning task was performed, each trial with imagery of varying value and relatedness. The second experiment was conducted in order to assess the imagery value of the conditional sentences used in Experiment 1. Both the imagery rating task and the task materials were from the first experiment. They explain that their results suggest that, “schema accessibility and mental imagery jointly were important in the reasoning process.” They stated that the Relationship between mental imagery and schema accessibility is essential to the reasoning process, while the imagery facilitates working memory. Essentially, the more content one has access to and can actively create interconnections between, the better they perform when tested for comprehension. Relatedness (R) allows us to access schema and leads to elaborative processing which leads to inferences as well as as a check on validity itself.

Gopnik et. al. 2004 [54] explored the causal structure of the world and how children use that structure to learn content that has typically a steep learning curve. In their research, they hypothesized that,“children use specialized cognitive systems that allow them to recover an accurate “causal map” of the world: an abstract, coherent, learned representation of the causal relations among events.” They found that a possible method for causal learning and inference in children is computations that resemble the learning and prediction process for Bayes nets, which simply put, are representations of multiple variables and their dependencies (or a web of causality). Their experiments indicated that children ages 2 to 4 years old were able to construct such causal maps, and their learning process was similar to the “Bayes net formalism” in which they saw far more than simple one way relationships among things.

Additional research by Green 2010 [55], examined how memory is a function of linking thoughts to one another. He said, “recent research has shown that some people who lose their memory also lose the ability to connect things to each other in their mind.” He notes that connections are what makes memory powerful, for example, connections one makes when they make a mistake. Memory is the method by which events that happen are connected to the consequences of events (actions or decisions) so that the person does not repeat that same mistake. Green also shows that when one’s hippocampus is damaged, the ability to make new memories, and to learn complex associations is lost, which can lead to amnesia. The ability to make connections also allows humans to conceive of the future. “Put enough of these item associations together, and you will create a web of connections that can help you make predictions and navigate the world more effectively over time.” Connections made by the brain, also create sentimentality, that is, connections are the *root of why people feel sentimental* in the first place. Green suggests that the reason that humans have such a developed ability to make connections is that we are social beings. He writes, “social interactions can pose our greatest predictive challenges and may well have been a major impetus, among our pre-human ancestors, for the evolution of astounding learning abilities” to make relationships between and among things, concepts and emotions.

In nature the stakes are high. Evaluate a situation incorrectly and you could end up dead. Pit vipers are venomous snakes, using their venom to catch prey and defend against predators. However, they have a limited amount of venom. Pit vipers, according to Piao et al. (2021), make different and strategic defensive decisions depending on the amount of venom they have left [56]. Snakes with a normal reserve of venom behaved in a predictable manner. Snakes with lower venom reserves fled more often and attacked significantly less. Once pit vipers replenish their venom, their behavior matched snakes with a normal reserve of venom (i.e., the control group) [56]. This means that snakes can Distinguish between levels of venom in reserve and draw Relationships between their venom reserves and the possible outcomes of a threat Pit vipers’ ability to make Distinctions and draw Relationships leads to greater adaptability and ultimately, more successful defensive behaviors.

“A growing body of evidence in cognitive psychology and neuroscience suggests a deep interconnection between sensory‑motor and language systems in the brain” according to Chersi et. al. 2014 [57]. Building relationships causes a change in the brain via the neuronal pathways and a corollary action and lexiconal coding (language systems). Examining relationships from a cognitive neuroscience perspective shows that, “neurons responding to the same stimulus or class of stimuli tend to cluster together to form topologically connected areas similar to those observed in the brain cortex.” To test this idea, two experiments were conducted to explore sensory-motor and lexical chains (sequences of related words seen in written text, both in sentences, passages, or the entirety of written works). The first experiment used a sequence of "goal-activated motor chains" to test the interplay between frequency, competition, and familiarization within these chains. Each chain started with a goal (e.g., eat the food), followed by the motor acts taken to succeed at the goal (e.g., grab, bring to mouth, etc.). The results of this experiment showed "evidence of different pools of neurons being activated by goal-specific motor acts emerged as the result of a process of adaptive specialization of long-term memory circuits for serial cognition." The second experiment had a similar goal, but used verbs as the starting stimuli because they have a multitude of ways they can be used in terms of tense and mood. In other words both experiments offer that the relationship drawn among motor and lexical chains are key to understanding. Overall, the article makes the point that Relationships and the systems of data support many critically important processes such as language development, working memory, and sequencing of information. Experiment 1 focused on the activation of lexical chains (language) in relation to motor (movement) behavior. Experiment 2 examined how language (lexical chains) develops through the perceived relationship to other sequences of letters out of context. In other words, Chersi offers that the formation of lexical chains relies heavily on the surrounding context. Further, creating lexical chains *without the context of word recognition in surrounding text* was not able to be simulated. The results of this experiment showed that neural coding of information thereby requires *associations and relationships among concepts* regardless of the form in which they come, whether it via sensory-motor or lexical (language) inputs.

The analogy is a common tool in which "new words and inflections are created on the basis of regularities in the form of existing ones[13]." Ferry et. al. 2015 [58] researched the ability to process analogies in infants aged 7 to 9 months old. Analogical ability is defined in the text as, "the ability to make relational comparisons between objects, events, or ideas, and to think about relations independently of a particular set of arguments." They outlined three possibilities for how analogical ability develops. First, it is innate—infants are born with skill in a series of basic relations (including the same/different Relations). The second possibility is that infants are born with analogical ability that allows them to be able to process and abstract relationships from their experiences. And lastly, the third possibility is that, "analogical ability is not an inherent capacity but is formed by combining more basic processes, guided by cultural and linguistic experience." Ferry et. al. did two experiments to test this, but the first was an unsuccessful replication of Tyrrell et. al. 1991.

For the second experiment, the major question was, "Can infants derive abstract same–different Relations from a brief series of examples, and if so does this learning process bear the signatures of analogical learning?" In this experiment, 64 healthy, full-term infants participated, roughly half were ~7 months old and the others were ~9 months old. Half of the infants were assigned the "same" condition, and half of the infants were assigned the "different" condition[14]. While in the waiting room, the infants were exposed to some of the toys, as pictured in Figure 15 (top is same condition, bottom is different condition):

[13] Definition from https://www.merriam-webster.com/dictionary/analogy
[14] In the waiting room infants saw a subset of the individual toys before the experiment. Infants were habituated to four pairs of objects, either same or different. In six sequential test trials looking time was recorded to the novel and familiar relational pairs in three different types of test trials (object experience, object experience + pair habituation, and novel).

Figure 21: Examples of toys.

For the familiarization trials, the infants were exposed to a series of objects that were either the same or different. The 4 groups of stimuli are pictured in Figure 22:

Figure 22: The 4 groups of stimuli.

There were then six test trials done, in 3 categories: object experience, object experience and pair habituation, and novel items. The infants looking time was measured to indicate preference.

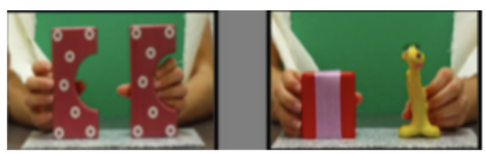


Figure 23: Object Experience.

Figure 24: Object Experience and Pair Habituation.

The results of their second experiment were significant. Generally, their results suggest that infants are able to abstract the same/different Relations. They found that the infants looked significantly longer at the novel pair than the others for both the same and different conditions, which is in contrast to their initial replication. This meant that the infants "successfully generalized the abstract relation to new objects presented for the first time in test trials." Ferry et. al. also found that there was no difference between the way infants responded to the same relation versus the different relation. It seems infants make relationships and are even capable of abstracting relationships of a particular type (in the case of this study, sameness and difference). This is critically important, because it means that not only are (1) infants (and one might conclude therefore adults) cognitively prone to making relationships, they are also (2) capable of abstracting them and/or utilizing abstract Relationships (i.e., "Rs"), (3) but also that infants are able and prone to distinguishing relationships (i.e., RDs), which is an important implication of DSRP Theory. In other words, while Relationships can be abstracted universally as a purely structural cognitive act, they are also content specific (that is the relationship itself is distinguishable by additional informational content such as “sameness” or “difference” or perhaps countless other content variables).

Kominsky et. al. 2017 [59] discusses “causal perception” which is a Relationship. There were 3 experiments done, one of which had two sub experiments. In experiment 1a, a visual search task in which the search array consisted of a set of two-object events was performed. There were four conditions (causal, temporal offset, spatial offset, and slip event). There were discs presented under the four conditions and the “subjects were instructed to press the spacebar as soon as they detected the pair in which the two discs were moving at different speeds (i.e., the asymmetric event). After they pressed the spacebar, the animation paused, and they used the mouse cursor to select the asymmetric event.” The 85 subjects performed this task, approximately twelve for each condition. For experiment 1b, practice rounds were added, due to an issue with instruction understanding in experiment 1a. The stimuli used were the same as the first part of the experiment, however there were only two conditions used (an asymmetric-target condition, identical to the causal condition in Experiment 1a, and a symmetric-target condition). In the discussion, the authors concluded that, “Experiment 1 demonstrated that adults’ causal perception distinguishes between triggering and launching events… provided initial evidence that causal perception, independently of judgment or reasoning, is sensitive to a distinction between launching and triggering.” This could mean that Relationships are sensitive to Distinctions, and that the two must function with each other, not separately.

In the second experiment, there was only one event on the screen at any given time, instead of three. Otherwise, the stimuli in this procedure were very similar to the stimuli in experiment 1b. “All of the events were two-object events, in which the two discs (A and B) could move either at the same speed or at different speeds, and this varied across trials (but not within a trial).” They found that in testing these kinds of physical Relationships, that sensitivity to speed had an impact on their results in experiment 1b.

For the third experiment, they tested the age at which this kind of cognitive processing happens. For each of the previously discussed four categories, they got approximately 34 infants in between the ages of 6 ½ months to 10 months old. For the infants, there was a habituation phase and a test phase. The infants were shown electronic animated stimuli and their looking time was measured. Once the infant had looked away for two continuous seconds, the trial ended. Their results showed that infants are capable of noticing and being interested in “categorical boundary between launching (1:1 and 3:1 events) and triggering (1:3 events).” They wrote, “our three experiments reveal categorical boundaries within causal perception—boundaries that are defined by an interplay of physical and perceptual constraints.” Overall, these experiments showed that causal perceptions are seen in seven to nine month old infants. This early-on development of Relationships indicates that *Relationships are therefore an inherent part of human thought*. It is clear that the cognitive, emotional, and conative ability to make Relationships is essential to the process of thinking. But what is the elemental or atomic structure of these all-important Relationships? To answer this, let’s look at a few more studies.

B: Relationships Have an Action-Reaction Structure

Newton's Third law states that for every action there is an equal and opposite reaction. Although applied to physical bodies in physical interactions, Newton's Third Law is extrapolatable to other domains, if not directly, metaphorically. As shown in the Ebbinghaus illusion, where the proximity and size of the surrounding circles affect the perception of the size of the central circle, there are a complex of interactions (sometimes referred to as "context") that affect outcomes.

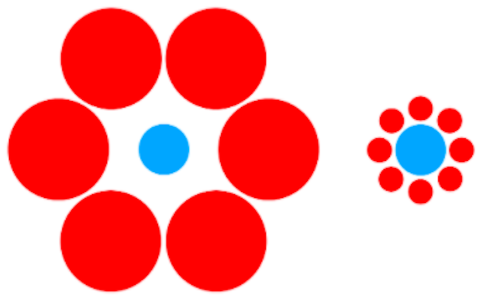


Figure 26: Ebbinghaus illusion.

In other words, the surrounding circles (and their proximity) are acting upon the center circle and vice versa. The net effect of these action-reaction chains is the relative perception of size.
Newton's Third Law expresses this action-reaction property where if A and B push against each other (action), they both move away (reaction) from each other. Indeed, even if only A does the "pushing," the same effect results.

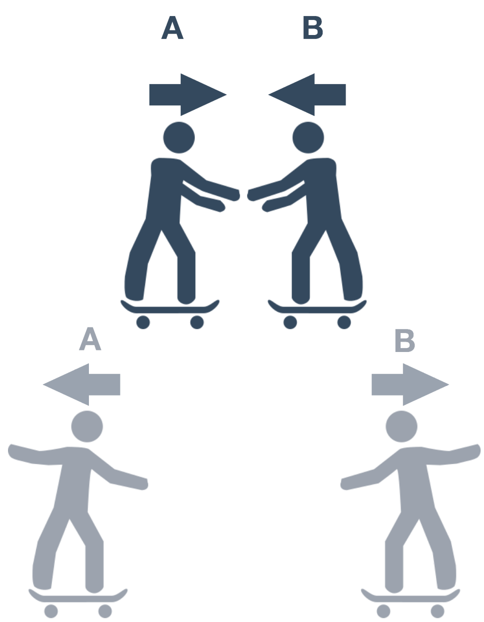


Figure 27: Newton's Third Law (Action-Reaction).

The relational and interconnected nature of human cognitive processes has a similar analog. When ideas meet, they affect one another.

There is a widespread tendency to think of relationships as one thing leading to another, or cause and effect. Harris et al 1996 [60] wrote that, “research on children's causal thinking has emphasized the perception of temporal and spatial contiguity between cause and effect.” Three experiments were designed to test a child’s ability and capacity for counterfactual thinking. Counterfactual thinking refers to the human tendency to create possible alternatives to events that have already occurred that are contrary to what actually happened. This is manifested in statements like "What if?" and "If I had only...". It is our desire to entertain how things could have been different, literally, counter to the facts of how things happened in reality.

In the first experiment, “children aged 3-5 years observed a sequence such as A causing B.” The children were able to accurately reply to a question relating to a counterfactual sequence (for example: "What if A had not occurred, then B or not B?"). For the second experiment, the children were asked about “two counterfactual antecedents”, one that would not have caused B, and one that would have also caused B. The children were able to differentiate between both types of antecedent. In the third experiment, children were told stories where the protagonist chose a course of action that either, “led to a minor mishap (e.g., drawing with a black pen and getting inky fingers), having rejected an option that would have prevented it in experimental stories (e.g., using a pencil) or an option that would have led to an equivalent outcome in control stories (e.g., using a blue pen).” The children were able to identify the protagonist's failure to choose a different course of action as the cause of the mistake. In the experimental stories, the kids chose to focus on the rejection of the alternative option. Overall, this research demonstrates that young children have the ability to recognize and articulate the action and reactions within Relationships.

Additional research conducted by Mascalzoni et. al. 2013 [61] explored “the question of how humans come to perceive causal relationships [that] has long been a challenge both for philosophers and psychologists.” They studied the presence and use of causal reasoning in newborn children in three experiments. The first experiment tested whether newborn babies were able to Distinguish and have a preference for a causal vs. a non-causal event. The causal stimuli presented was a two object event with apparent causal motion with spatial and temporal continuity, while the non-causal stimuli was characterized by temporal discontinuity. They said that, “the delay event, in fact, was identical to the launching one except for the presence of a 1-s delay between the time of contact and the motion of the second object.” The ages of the newborns ranged from 8 to 71 hours old. A preferential looking task was used to gather data, and while measuring, distractions were minimized to the best of their ability. The newborns showed a significant preference for the causal event over the non-causal ones. For the second experiment, the stimuli were the same, except for the spatial parameters. “Both stimuli in Experiment 2, in fact, were characterized by a discontinuity between the trajectory of the two objects involved in each event.” The procedure was identical to experiment one. This experiment resulted in the conclusion that “the spatial continuity of trajectory between the motion of the two objects appears to be crucial in determining newborns’ preference.” For the third experiment, the purpose of the experiment was to test the role of the “temporal sequence between the motion of the two objects in triggering newborns’ preference.” The causal event was the same as in experiment one. The non-causal Relationship differed in that object B moved first, then object A moved. The non-causal stimuli is inverted. The procedure was identical to experiment one. The results showed that the newborns were able to Distinguish between the event and its inverted form, and they still showed a preference for the causal events. They wrote that, “overall, newborns seem to be sensitive to the additive effect of a set of perceptual cues (i.e. temporal continuity between the motion of the two objects involved in the event, continuity of trajectory between the motion of the two objects, and the sequence of the displacements of the two objects) which are crucial in determining perception of physical causality in adults.” This study demonstrates a newborn’s visual perception of causal relationships, and it’s similarity to that same mechanism found in adults.

Rolfs et. al. 2013 [62] discussed how seeing the Relationships occasionally depends on the immediacy of the cause and effect principle. They stated that if there was a delay between the causal node of the Relationship and the subsequent effect, then the person could miss the Relationship entirely. “The perception of causality involves two components, one that is stimulus based and one that is inference based.” They completed three experiments, the first of which was testing the adaptation to collision events. The collision stimuli they used were two discs bouncing back and forth, clearly causal to each other. The subjects had to watch the discs and determine where the “point of subjective equality” was. One test group had the locations adapted, while the other did not. The results were that, “events that were perceptually ambiguous before adaptation were now judged to be noncausal passes in the vast majority of trials; events that were regularly perceived as causal before adaptation had now become ambiguous.” The second experiment was set up functionally the same as the first, except the stimulus was a slipping disc instead of the swinging discs. The point was to test “whether adaptation to other visual features of the adapting stimuli might explain the change in observers’ judgments of causality.” However, in this experiment, there was no change in perceptual causality. In the final experiment, they sought to determine the “reference frame of adaptation.” In order to test this they measured eye movements with one side of fixation. “The present findings take an equally important step toward determining how the brain parses events and assigns causal links, which paves the way for tracking down the neural mechanisms underlying these visual processes.” Humans have the ability to “fill in the blanks” between cause and effect in the case of predicting where a ball will land once it’s been thrown in the air for example. The brain (using vision and visual cues) can then parse through events and assign a relationship or a causal path in real time.

C: Metacognitive Awareness of R(a ↔ r) Structure Matters

Yet, while we know that we have the *ability* to make relationships, often we make them without an *awareness* that we are doing so. In other words, metacognition requires recognition and explication of the relationships we make between and among things whether they are people, concepts, or other ideas. Schultz and Gopnik (2004) [63] researched causal learning across domains. They completed five experiments that concluded that children can, “make causal judgments using patterns of independent and dependent probabilities across a range of tasks and domains.” Their research (using a screening-off technique) showed that when screening off information, preschool aged children were able to learn the causal Relationships within both biological and psychological events. Furthermore, they saw an impressive ability from the subjects (3-4 year old children) to draw causal Relationships from dependence patterns. This data is indicative of the power and prevalence of Relationships, and how early they come into play cognitively. In particular, it shows that young children can learn to be more cognizant of the relationships they make in their mind; as a powerful tool to understand new concepts.

Additional research by Dhamala, 2015 [64], explored the nature and importance of causality *as a tool for gaining deeper understanding*. They argue that the neurological research on causality is important to science as a whole and should be applied more readily. “A living brain is a complex dynamical system with many highly interconnected, interacting and self-organizing entities (neurons). The traditional notion of brain regions as information-processing units, with an input, a local processing capability and an output is too rigid and is not generally applicable throughout the brain.” They offer that the nature of causality is not yet well known, and therefore application to a broader range of subjects and sciences could greatly increase the understanding of causality itself, and the utility for deeper understanding of any content. They also say that it is naturally hard to see the brain as a fluid entity rather than as a black box of inputs and outputs; because the latter is much simpler and easier to deal with when trying to solve problems and answer questions. The human brain is considered to be one of the most complex systems in the universe. “There are many mysteries to be solved including the patterns of causal relations among brain regions during perception, cognition and behavior.” That relationships exist in mind and nature is established, such that the new emphasis needs to be one increasing human awareness of them and the power in seeing the relationships we make as a tool for building meaning from new inputs.

Sanefuji and Haryu 2018 [65], studied the Relationship between a preschooler’s development of theory of mind, and their understanding of causality. They did two experiments, the first of which was designed to test if the children could arrange pictures in a predetermined sequence. There were different types of stories used that were about mechanical (objects interacting in a casual Relationship with each other), behavioral (people interacting), or psychological (people interacting with regards to mental state) causality. After performing this test, they did a false belief task as well. The results of the experiment indicated that there was some Relationship between successful picture sequencing and success in the false belief task. In the second experiment, the children that failed the false belief task were the subjects. They were given the same false belief task as in the first experiment. The experiment showed that the children who performed better on the psychological stories in the first experiment, did better on the second false belief task. Overall, the study showed that, “the findings of the present study indicated that children who cannot understand others' false beliefs are able to understand and enjoy stories containing false beliefs.” In other words, conscious establishment of sequential relationships in the first experiment also increased the subject’s ability to take new perspectives and see alternatives to the sequence as it played out.

5. Point-View Perspectives

Perspective-taking (P) is the act of looking at things using a point and view. In other words, explicitly working with concepts using one or many points and views, while being aware of the relationships, systems, and distinctions between them. Infants show evidence of Perspective-taking as early as three years of age, while experiments with adults show the varied and sophisticated ways Perspective-taking is used across the lifespan. A review of peer-reviewed journals across disciplines indicates:

1. The existence of Perspectives (i.e., P as a noun/object);
2. The act of Perspective taking (i.e., P as a verb/action);
3. That the relationship between “point” and “view” (i.e., $P(\rho \leftrightarrow v)$ is elemental to (1) and (2) above; and,

4. That the human tendency is to take one's own Perspective and marginalize the Perspective of the other.
5. In summary, it shows that items 1-4 are fundamental "patterns of mind" agnostic to content area (across disciplines) and throughout the lifespan of humans. Where Perspective taking is concerned, the difference between thinking (ie., cognition) and systems thinking (i.e., systematic metacognition) is not in the $P(\rho \leftrightarrow v)$ structure of cognition itself, but in the willful and purposeful attempt to see (i.e., be aware of) the $P(\rho \leftrightarrow v)$ structure that is at work when thinking.

Many sources relevant to Perspectives were found in peer-reviewed social psychology, cognition, and psychology journals. The understanding of Perspectives in the literature (and related search terms such as point of view and theory of mind) demonstrated the power and unknown influence that perspective-taking can have on interpersonal, professional, and reality-based relationships.

A: Perspectives Exist in Mind and Nature

Like Distinctions, Systems, and Relationships, Perspectives exist in both Mind and Nature. They are real things (exist in reality) and they are conceptual things (things we think) and sometimes they are in alignment with one another. And, Perspective-taking is a universal cognitive structure—we cannot think a thought, without also taking a Perspective.

It is perhaps a reasonable a priori assumption that no thought happens absent of the perspective of the thinker. To think is to isolate some set of things from the universe of things and because it is impossible to "boil the ocean" by thinking every single thing in a single thought, it is a priori that any given thought is therefore only a slice of the whole (usually an infinitesimally small slice). Ergo, in order to decide which slice to focus on and which slice not to (a Distinction), is by definition Perspectival. In addition, some other person, perhaps considering a similar thought or slice of the whole, may select a different set of things to focus on. Although there is ample empirical evidence that illustrates this, as a global statement of the nature of how things work, it is essentially an a priori fact.

Earlier research into perspective taking focused on the development of theory of mind, which is simply the ability to attribute beliefs, thoughts or feelings to another person (take another's perspective). Marvin et. al. 1976 [66] researched the development of conceptual Perspective taking in the early years of life. They identified two types of Perspective taking: perceptual and conceptual. They define conceptual Perspective taking as, "an inference a child makes regarding those less tangible aspects of another's internal experience such as his thoughts, desires, attitudes, plans." At this point, both types of Perspective taking had been thought to develop at around 7 years old. However, through their research, they determined that conceptual Perspective taking occurred in children as young as 4 years old. Remarkably, they were not just able to take the Perspective of one individual but were able to take the Perspectives of up to three individuals.

Premack and Woodruff (1978) [67] explored the possibility of chimpanzees having a theory of mind. In order to test this, they showed chimpanzees videos of humans experiencing problems. For example, the videos featured problems like food being out of reach, the actors being unable to get themselves out of a locked cage, the actors being cold due to a broken heater, and an actor not being able to use a phonograph because it was unplugged. To see if the chimpanzees could take the Perspective of the actors in the videos, they were shown a few cards with photos on them, one of which had the solution to the problem on it (stick, key, lit match, etc). The chimpanzees consistently picked the card with the appropriate solution on it, which indicates that the chimpanzees were able to take another's Perspective, understand the problem they face, and identify the needed solution. This is evidence that Perspective-taking is not just a human cognitive process, but is potentially found throughout the animal kingdom as well.

Birds are able to take Perspectives as well. Endler 2012 [68] researches the fascinating mate-display building behavior of Bowerbirds. They build what is called a bower, shown in Figure 27.

Figure 28: Example of a bower.

They then decorate their bower with a series of uncolored and colored objects, taking the Perspective of color into account. Great bowerbirds take another Perspective: size. They organize their colorless objects by increasing size further away from the bower, creating a geometric pattern. This can actually allow the male bird to create forced Perspective and entice females to their bower (Figure 28).

Figure 29: Forced Perspective created by the Bowerbird.

Some Bowerbirds dive deeper into the color Perspective and sort their brightly colored objects by color as well, shown in Figure 29.

Figure 30: Color Perspective created by the Bowerbird.

All of these Perspectives are taken in order to attract more mates, and research shows that it works. It works because the male Bowerbirds are not only using Perspective to make a more appealing nest, but their use of Forced Perspective demonstrates that they also have a Theory of Mind. The birds who are better at creating these displays and taking multiple Perspectives get more mates overall. The ability to take multiple Perspectives has evolved into Bowerbird's mating process over time, resulting in birds that can create illusions and beautiful displays.

The Theory of Mind idea is a common way to test if an organism is taking perspectives other than its own, and to what degree it is able to do so. Chimpanzees and some other primates have been shown to be able to perform in Theory of Mind tasks. This research by Thomas Bugnyar et al. 2016 [69] demonstrated that ravens (*Corvus corax*) also have the ability to take perspectives. A concern with the experimentation of non-human organisms in Theory of Mind tasks is that the test subjects could be possibly using the eyeline of the human experimenter to gauge what is needed to be done to complete the task. This experiment was performed without the experimenter in the room, so that concern is mitigated. Their experiment entailed three conditions to measure the test raven's caching[15] behavior: observed, non-observed, and peephole. In the observed condition, the window between both ravens is open, and both are vocalizing. In the non-observed condition, the window is covered so neither bird can see the other, and both are vocalizing. Finally, in the peephole condition, one of two peepholes in the window is opened. Their results showed that the ravens had similar caching behavior in both the observed and peephole conditions, indicating that they are aware that there is a possibility for their food store to be seen through the hole. They also used the perceived limited visual range of the peephole to move their cache out of sight. Their results suggest "that ravens can generalize from their own perceptual experience to infer the possibility of being seen." Incredibly, as more and more research is done, we find that perspective-taking is not unique to humans, and is in fact universally performed by all kinds of organisms.

Including organisms you might not initially expect to be capable of cognition. Plants have been shown to take Perspective in two pieces of research. Daniel Chamovitz [70], in his popular book *What A Plant Knows*, explains that plants are incredibly complex sensory organisms. In particular, plants can signal danger to their neighbors. If a Maple tree is attacked by insects, it expels a chemical which signals to the surrounding Maple trees to produce insect defense chemicals. It may be too late for this tree, but it puts energy into protecting the nearby members of its species. Another example Chamovitz gives is in a time of drought. Some plants can communicate via their root systems, and if one of those plants is experiencing a significant decrease in water availability, it signals this to the other plants which leads them to prepare for a lack of water in the future. This Perspective-taking behavior doesn't end there. Montesinos-Navarro et al [71] researched how plants who take care of one another benefit long term from their "kindness." Their research showed that adult plants in a harsh environment aided the juvenile plants, and everyone was better off because of it. The mature plant in a hot desert environment that shelters a seedling from the elements was shown to, over time, has more flowers than a plant of the same size who isn't helping out others. Both of these findings show that Perspective-taking is done by plants, and it has (in some cases) even evolved to be beneficial to those that participate in helping others.

Gagliano et al. [72] researched a sensitive plant's (Mimosa pudica) ability to obtain information from its environment and if the plant adjusted its behavior based on the information it gathered. Specifically, the sensitive plant has a defensive leaf-folding behavior that the plant exhibits when it perceives a threat. Gagliano et al. wondered what the plant would do if it was exposed to a stimulus it would never normally encounter in the wild. They dropped the plants from a height of 15 cm. This made the plant fold its leaves. However, as they dropped the plant over and over, the plants learned that there was no need to defend themselves. They eventually stopped folding their leaves. The plants drew a Relationship between being dropped and a threat, but realized that it was an inaccurate and energetically-costly Relationship to be

[15] Caching is a behavior where an organism stores or hides away its food for future use.

drawing. The plants retained their learning even after being left on their own for a month. These findings show that Perspective-taking is done by plants, and it has (in some cases) even evolved to be beneficial to those that participate in helping others.

Humans regularly engage in "prosocial behavior" which is thought to be motivated by a feeling of empathy for others. The purpose of Ben-Ami Bartal et al.'s [73] research was to explore if rats would also engage in prosocial behavior if they had the opportunity. In their experiment, they placed a free rat into the test area which contained either an empty restrainer (for the control) or a rat trapped in the restrainer. The rats placed in the experimental setup worked hard to free the constrained rat, while the ones in the control did not attempt to open the restrainer. They then did an experiment to see if there was a stimulus that would encourage the rat to be selfish (anti-social) if it would change the behavior of the rats. The experimental arena was changed to include an additional restrainer which was full of chocolate. The rats worked to open both restrainers, and in most of the experiments, they shared the chocolate with the freed rat. This experiment shows that rats have the ability to take Perspective and have empathy for another of their species. Their Perspective taking ability leads them to do extra work in order to make another rat less miserable. The root of empathy is Perspective, which is fundamental to social organisms. Without it, we would not be able to coexist with one another. To increase empathy among us, we must start with building perspective taking skills, a fundamental element of systems thinking.

As shown thus far, social behaviors have developed in many species due to their ability to both take Perspectives and draw Relationships. Satoh et al. (2021) [74] demonstrated that cichlids (fish) were able to make both prosocial and antisocial decisions as their contexts changed. Their experiment put male cichlids in a variety of situations to see how social they would be. The fish were given two choices: an antisocial one (eat the food alone) and a prosocial one (share the food with others). To determine their choice, another fish was placed in a tank in sight of the male cichlid. Satoh et al. explains the results:

> " ...male subjects learn to favor prosocial choices when their mates are the recipients in a neighboring tank. When the neighboring tank is empty, males choose randomly. Furthermore, in the absence of their mates, males behave prosocially toward a stranger female. However, if the mate of the subjects is also visible in the third tank, or if a male is a potential recipient, then subjects make antisocial choices (pg 1, [74])."

This means that make subjects Relate their behavioral choice to the mates in the neighboring tank. If the neighboring tank has a mate in it, they choose procosically. If the neighboring tank has a stranger female, they act prosocially. If the neighboring tank has a rival male, the act antisocially. The male cichlid Distinguished between the different social situations and Related their behaviors to each. As Satoh et al. writes, "Individuals of this species can visually distinguish between familiar and unfamiliar individuals and change their behavior depending on the social relationship (pg 2, [74])."

Perhaps the most known work about theory of mind is Baron-Cohen et. al. 1985 [75] who wrote the paper that developed the concept of a "theory of mind," through their experiments and analyses on children with autism. They developed the Sally-Anne test, which is a psychological test designed to see if one can attribute a false belief to another. The Sally-Anne test is depicted in the image below:

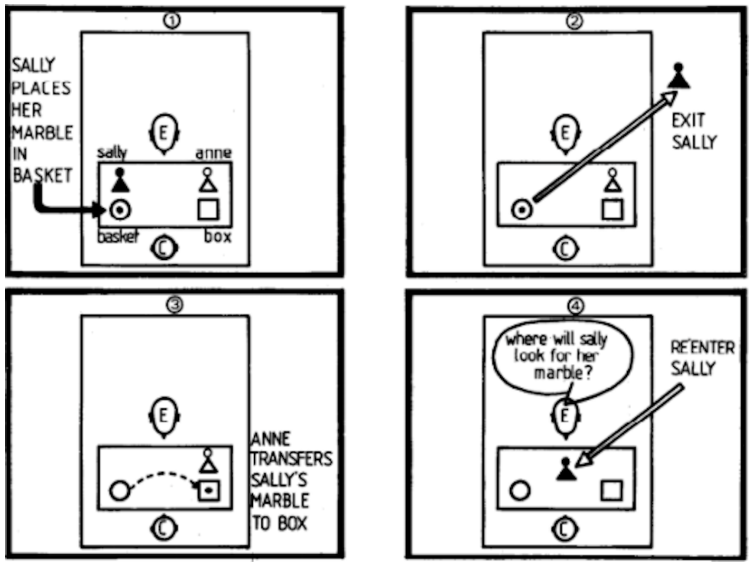


Figure 31: Sally-Anne Test.

> *There were two doll protagonists, Sally and Anne. First, we checked that the children knew which doll was which (Naming Question). Sally first placed a marble into her basket. Then she left the scene, and the marble was transferred by Anne and hidden in her box. Then, when Sally returned, the experimenter asked the critical Belief Question: "Where will Sally look for her marble?" If the children point to the previous location of the marble, then they pass the Belief Question by appreciating the doll's now false belief. If however, they point to the marble's current location, then they fail the question by not taking into account the doll's belief (page 41).*

It is designed to test if the children can step out of their own Perspective and take Sally's. Their results after testing both normal and autistic children showed that while the normal children pointed to where Sally had put the marble in the first place, the autistic children however, pointed to where the marble had been moved. Theory of mind, which is a form of Perspective taking, is a process of the psychological development of children.

Vallar et al 1998 [76] investigated how the brain creates an "egocentric spatial frame of reference" using an fMRI. In particular, they observed the mid-sagittal plane, which divides the left and right sides of the brain. In the fMRI machine, the 7 participants were instructed to press a button when a vertical bar that was moving horizontally, passed their "subjective mid-sagittal plane." Control group participants were instructed to press the button when the bar changed direction, instead of when it crossed the mid-sagittal plane. They observed an increased signal in, "posterior parietal and lateral frontal premotor regions, with a more extensive activation in the right cerebral hemisphere." Their finding that the formation of an egocentric spatial frame of reference is located in the right hemisphere corresponds with previous research in people with lesions in that same area. "Damage to the right hemisphere, more frequently to the posterior-inferior parietal region, may bring about neglect syndrome of the contralesional, left side of space, including a major rightward displacement of the subjective mid-sagittal plane." In other words, having an injury on that specific part of the brain, will affect one's ability to create a spatial frame of reference. This research is significant to us in particular because it demonstrates a neurological placement for taking perspective, specifically a spatial one.

Renowned physicist Freeman Dyson [77] states, "... mind is already inherent in every electron, and the processes of human consciousness differ only in degree but not in kind from the processes of choice between quantum states which we call 'chance' when they are made by electrons." It is difficult to be sure if Dyson is speaking metaphorically or empirically. However, Zwick's et al. [78] answers the question empirically with their research on the ability of a probe (qubit) to sense unknown measures of a molecular, atomic or quantum environment. Their research makes it clear that atoms have a sensory perspectival experience of their environment. Qubits (quantum bits) "are sensitive probes of the structure and properties of highly complex molecular, atomic, or solid-state quantum systems" Zwick explains [78]. In their research they were particularly interested in using the a qubits unique perspective to extract information about its environment by monitoring the qubit's decoherence[16] process, "atoms are actually sensing through interactions (similarly as we do) their environment, and change their behaviour accordingly" [79].Their research demonstrates that qubits have a perspective on their molecular and atomic environments which can be used for important gains by, "[extracting] information from the behaviour of atoms acting as sensors, to try to reconstruct indirectly the information from their environment. In particular, we are exploiting this property to develop novel diagnostic tools using magnetic resonance imaging, to be able to see deep inside biological tissues and their structure in non-invasive ways" [79]. Therefore, molecules, atoms, and quarks have a frame of reference. The Perspective pattern is fundamental not just to the mind, but also in nature, in the most fundamental elements of the universe itself.

Ruby and Decety 2004 [80] researched the neurological process of perspective-taking using a positron emission tomography (PET) scanner. The ten participants of the study were asked to either adopt their own or their mother's perspective in response to an assortment of situations. Some of the situations required social emotions, and others were neutral. Each subject was scanned 12 times to eliminate as much machine noise as possible. The main result of the first person/third person was, "hemodynamic increase in the medial part of the superior frontal gyrus, the left superior temporal sulcus, the left temporal pole, the posterior cingulate gyrus, and the right inferior parietal lobe." The amygdala was also activated when looking at both the self and others perspectives. This study demonstrated that perspective taking has a neurological basis, and there is not "a single mechanism that accounts for the perspective taking process." This means that the perspective-taking process is facilitated by multiple locations within the brain.

Research indicates that perspective taking is likely a fundamental process of human cognition. As such, many scholars began to study more specific aspects of perspective taking as developmental skill. Russell et. al. 2010 [81] examined "episodic future thinking" children ages 3 to 5 years old. He conducted four experiments to explore children's ability to "think of what will be needed from a different point of view." The first experiment tested if children could pass a "blow-football" by playing a game in which the child uses a straw to blow a ball into a goal across from them. They performed this task both in a present *self condition* and also the *past other condition* (i.e. someone performing the task in the past). All of the

[16] "**Decoherence** is the **process** by which information of a quantum system is altered by the system's interaction with its environment (which form a closed system), hence creating an entanglement between the system and heat bath (environment)(cite wikipedia definition)"

children were able to do the task in both conditions successfully, confirming the original hypothesis. The second experiment was similar to experiment one, but the conditions the children were put through were the "*future-self*" and "*future-other*" conditions. Their results showed that processes such as future thinking begins at approximately four years of age. This is due to an ability to perform Point of View thoughts. Findings from experiments 1 and 2 justified the examination of a spatial **and** conceptual approach to episodic cognition in the third and fourth experiments for four year old children only. In the third experiment, the main finding was that, "this experiment demonstrates clearly that children of 4 years of age find a *future-self question* more challenging than a *future-other question.*" The main finding for the fourth experiment was that "self-directed questions are not generally more difficult than other-directed questions, as there was no difference in difficulty when they were asked in the present tense." Interestingly, 4 year olds struggled more with future conditions of themselves, than they did but for others. The general discussion alludes to a pivotal point in child development at age 4 in which children's abilities to engage in future thinking and the self versus other distinction. In other words, in "perspective-taking tasks children of 4 will imagine how something looks from a point of a view they do not share." These findings show the developmental path and inherent nature of Perspective as a cognitive skill.

Rakoczy et. al. 2018 [82] explored and re-evaluated the past research that found that performance on theory of mind exercises declined with age, while tests on wisdom stayed relatively consistent with age. Through their experiments and evaluation, they found that this discrepancy could be due to, "the pattern of diverging developmental trends in perspective-taking measured in the established ToM [Theory of Mind] versus wisdom tasks is not necessarily specific to perspective-taking as such, but might reflect the general pattern of the development of cognitive capacities over the lifespan." In fact, the negative correlation disappeared with the theory of mind studies when they accounted for the difference in processing speed as one ages. They also found that when changing both tests to have novel ways of measuring theory of mind and wisdom performance, the performance difference due to age disappeared (practically), indicating that there could be something to the tests that made them difficult or not interesting to the older adults in the test. This indicates that theory of mind (and therefore Perspective taking) is a part of cognition throughout the human's whole life.

Additionally, perspective taking is thought to be the root of empathy. Mafessoni and Lachmann 2019 [83] researched the origins of empathy and emotional contagion. They looked at the possibility that empathy and emotional contagion originated from a cognitive process or function, and not only from social cooperation or coordination. They stated that, "contagious yawning, emotional contagion and empathy are characterized by the activation of similar neurophysiological states or responses in an observed individual and an observer." While organisms cannot read the minds of other organisms, they do share very similar minds to members of their own species. As a result, organisms seem to be "constantly running simulations of what other minds might be doing." This constant simulation isn't always geared toward cooperation but rather is something animals do spontaneously. Mafessoni and Lachmann also offer that the behavior of putting oneself as an actor in another's mind requires embodied cognition. Embodied cognition means that the mind is connected to the body, and the mind also influences the body. This plays out socially, "as an actor's cognition is embodied, even an observer's cognition is required to be embodied, despite the risk of accidental coordination." Thus, the spread of empathy and the contagion of emotion occurs in the mind and body, naturally. Perspective taking is therefore a needed cognitive act that bolsters emotional connection to others, which, as social animals, is essential for evolutionary success, in both humans and other animals.

B: Perspectives have a Point-View Structure

Perspectives exist in mind and nature, and therefore it would be beneficial to examine the form in which they occur. In other words, how do humans take perspectives? What are the underlying elements to the act of taking a perspective? Generally speaking there are two parts to a perspective: a point (an observer/looker); and a view (that which is being looked at).

Often perspective is seen as synonymous with how things are framed. In other words, how things are framed (a problem, issue or situation) is rooted in a perspective. Notably, the way things are framed often shapes the action's one takes, or decisions made. Tversky and Kahneman (1981) [84] studied the psychology of choice and its relation to the framing of decisions. They looked at the difference between the dependence on frames and the dependence of perceptual appearance on Perspective in general. They found that subjects bounced between finding one option better over the other, depending on how the choice was framed. A metaphor was used in the discussion, "If while traveling in a mountain range you notice that the apparent relative height of mountain peaks varies with your vantage point, you will conclude that some impressions of relative height must be erroneous, even when you have no access to the correct answer." They offer that the appeal of certain options is correlated with the frame itself. Such that changing the frame, can change the attractiveness of options, and therefore the decision made and actions taken. This is also the case with choice-making. Normally, discovering that your previous mental model is incorrect, the decision-maker could reconsider the framing and assumptions that were initially put in place, knowing that there is no true way to get a correct mental model. The underlying subjectivity of how things are framed necessitates an understanding (and awareness) of the root perspective from which it originated.

Additional research examined how perspective taking influences communication between people. Schober (1993) [85] researched how people took Perspective when describing the location of an object (or multiple objects), either to themselves or to others. He observed participants attempting to describe the location of objects either alone, or with a partner. The type, point, and view were the variables used to describe the location of objects in this study. Those who had to speak to an imaginary partner took Perspective with relative ease, while those who were given a real partner found that they had to choose between an *egocentric* or *other-centered Perspective*. However, Schober found that when the partners switched roles, the ones who had an egocentric partner would take an egocentric perspective, and the ones who had an other-centered perspective to their partner's Perspective. Also, there was an indication that perspective taking can be collaborative, with partners checking in with each other about their other-centered directions. Interestingly, this shows the many ways in which perspective shapes how we communicate with others, and also the need to be able to identify when communication is facilitated or hindered by doing so.

That communication is affected by humans ability to take their own or another's perspective leads to a similar interest in the role of perspective in understanding how one feels. Bateson et. al. 1997 [86] distinguished between two types of Perspective taking: thinking about how another person feels, and thinking about how you would feel in that same scenario. To test how these two types of Perspective taking differed, they did an experiment involving sixty students who were assigned to three possible conditions: to be objective, to imagine how the other feels, and to imagine how they would feel (20 people per condition). The participants listened to a tape of a girl describing how her parents had died in a car crash, and her struggles to take care of her younger siblings during her last year of college. The researchers measured the emotional reaction people had to the tape and found that the two groups tasked with (1) imagining how the other felt and (2) how they would feel in the other's situation both had emotional responses of empathy; with the latter also showing signs of emotional distress.

This difference is noted in particular as it relates to human motivation. In other words, there is a difference in why one feels something in relation to perspective taking exercises. The act of empathy, where you feel how the other feels is connected to altruistic motivations, whereas, putting oneself in another's position is correlated with egotistical motivation as well. This implies a benefit of taking Perspective, is not just to expand your worldview, but to also increase one's desire to help others.

The relationship between social dynamics and Perspective taking was also explored by Knowles, 2014 [87]. She completed three studies total, the first experiment was designed to test whether social rejection was related to a shift in Perspective from self-centered to other-centered. The experimental group was first asked to spend five minutes writing and reflecting on a time they felt rejected. They were then asked to perform a Perspective-taking exercise directly afterward. The participants who had to relive a rejection took other's Perspectives more often than the ones who didn't. The second study was designed to replicate the results and to assess the effort level of rejection-motivated perspective taking. The results showed that, "only highly motivated individuals—the rejected—marshal their limited resources to take another's point of view on a task requiring social coordination." The third study showed that "adopting another's perspective enhances individuals' memory for their social environment." When one is socially rejected, Knowles found that their ability and desire to take other's perspectives increases dramatically, even when the brain is cognitively busy (although to a lesser degree). There is also a relationship drawn between perception and behavior, as those who were rejected were hyper aware of facial expressions and vocal tone as an indicator of acceptance. As such, perspective-taking is foundational to our social interactions with others.

Spatial perspectives were studied by Cavallo et. al. 2017 [88]. Specifically, they examined how taking a spatial Perspective involves a process of mental "remapping" of the spatial environment from a different point of view. Three experiments were conducted. In the first experiment, participants had to "judge whether the apple was to the left or right from their own perspective and from that of the human avatar seated at the opposite end of the table." When viewing from the human avatar's Perspective, there was evidence to show that the participants spatially remapped the environment. The second experiment tested whether the remapping happened due to the presence of a human triggered spatial remapping. They wrote that as a result of their experiment, they found that, "remapping does not require the presence of a human avatar but simply the possibility of a human perspective." In the third experiment, the scene was changed so that a human couldn't possibly fit at the end of the table. As a result, the spatial remapping effect disappeared. This article demonstrates that the presence of the identity/other construct can deeply change the way one interacts with their environment. As an example of this, they wrote, “When responding from their own viewpoint, right-handed participants responded faster when the object was closer to and to the right of them. In contrast, when responding from the viewpoint of a human avatar seated facing them, participants responded faster when the object was closer to and to the right of the avatar.” Perspectives therefore can be anthropomorphic, physical, spatial and conceptual in nature.

C: Metacognitive Awareness of $P(\rho \leftrightarrow v)$ Structure Matters

While we tend to think of perspectives as anthropomorphic, it is equally important to be aware of the spatial, and conceptual perspectives we use to better understand things. Neale and Bazerman (1983) [89] studied if Perspective-taking has a role in the outcome of a negotiation. Their test included 240 students who engaged in two types of negotiation: conventional arbitration and final-offer arbitration. Results suggested that the type of negotiation **and** the use of Perspective-taking improved the outcome of their negotiations. They distinguished two types of Perspective taking: taking their own Perspective and taking their opponents Perspective. They wrote, “An opponent's Perspective-taking ability affected both process and outcome variables.” This supports previous research which found that negotiators behavior affects their opponent when it is in the realm of reciprocity and equity. However, they noted that experience with negotiation also had an impact on the participant’s success rate.

The potential that Perspective-taking has in reducing bias was examined by Galinsky and Moskowitz (2000) [90]. In their first experiment, they found that taking Perspective reduced both conscious and unconscious bias as shown with two tasks. In their second experiment, they looked at the participants' perceptions of the elderly. Their results showed that taking Perspective, “led to both decreased stereotyping and increased overlap between representations of the self and representations of the elderly, suggesting activation and application of the self-concept in judgments of the elderly.” And in the last experiment, Galinsky and Moscowitz found that in-group bias was reduced through Perspective taking. They concluded that if Perspective-taking increases, then negative biases could reasonably be reduced.

Takaku et al 2001 [91] researched the effects of perspective taking on apology and forgiveness in both Western and Eastern societies. Specifically, they looked at how much perspective-taking impacted apology acceptance in Japanese and American cultures. In order to test this, the 77 Japanese participants and the 102 American participants in the study were asked to read a short blurb where they were instructed to imagine that they were being mistreated by their classmates. Before they did this however, the participants were “randomly assigned to one of three perspective-taking conditions: (a) recall times when they mistreated or hurt others in the past; (b) imagine how the victimized classmate would think, feel, and behave in the scenario; or (c) imagine the situation as the personal victim.” After being given their instructions, the participants read their passages all of which were completed by a detailed apology from the classmate. Their results showed that when the participants took the perspective of the offender, they were “significantly more” likely to accept the offender’s apology. Apologies are one of the main ways conflict is resolved in today’s world. This research demonstrates that taking another person’s perspective can lead to apologies, forgiveness, and a better understanding of one another.

Perspective-taking in the workplace has value and can be predictive of “contextual performance.” Parker and Axtell [92] looked at Perspective-taking in the workplace. In this scenario an “internal customer adopts the perspective of an internal supplier.” They looked at two aspects: empathy and positive attributions. They stated that, “these findings suggest two ways to enhance supplier perspective taking and hence contextual performance: increase employee interaction with suppliers and enrich job content.”

Research was also conducted around the egocentric anchoring and adjustment people use to successfully take Perspectives (Epley et. al. 2004 [93]). In the first study, the focus was sarcasm, which can be viewed as an ambiguous communication. If the participants were primed with a negative stimuli they saw a message as being sarcastic, while if primed with a positive stimuli they did not. In the second study, responses to questions and statements would be more egocentric if one was under pressure, rather than if they had more time to think. “The results of this study further support our contention that adult Perspective taking follows a process of anchoring and serial adjustment. Because adjustment from one’s own perspective takes time, hurried participants adjusted less and were consequently more egocentric than those who responded at their leisure.” In the third experiment, participants were given Coke and Pepsi to taste test the difference between them. They were informed of the identities of the drinks beforehand. They were then told to estimate another’s ability to taste the difference. When speaking of themselves, respondents said the difference was obvious, but used a more moderate statement when discussing others perceptions of the taste difference. “These results offer further evidence that people adopt others’ Perspectives by initially anchoring on their own perception and then effortfully adjusting for differences between themselves and others.” For the fourth experiment, the influence of subtle body language cues (such as nodding or shaking one's head) was tested in relation to willingness to adopt another’s Perspective. Their results showed that nodding one's head led them to be more likely to adopt the Perspective, while shaking their head led them to be less willing to adopt the Perspective. In the final experiment, they tested if human Perspective taking was related to the concept of “satisficing”. This means, “given the uncertainty surrounding the true value being estimated, people are likely to have a range of values they would consider to be plausible estimates. In the absence of sufficient motivation for accuracy, people are likely to terminate adjustment once a plausible estimate is reached—arriving at a satisfactory estimate rather than the most accurate estimate.” They confirmed their hypothesis that humans have an egocentric bias, in which they view the world through their Perspective nearly 100% of the time. So the authors suggested taking another’s Perspective requires starting from their Perspective (their anchor) and then analyzing the differences between themselves and the other. In other words, they offer that people understand others by using themselves first as a lens. People vary in the amount of awareness they have of this bias, which can be an issue, as many social judgements are egocentrically biased which can be detrimental especially during a conflict.

Davis et al 2004 [94] performed two experiments to test how Perspective taking occurs. “In the first, a thought-listing procedure was used to assess observer cognitions; in the second, a less reactive measure was used.” The results of these studies showed a few things. The first is that when a participant is given instructions to take Perspective, they have more self-related thoughts. Also, people who were given the Perspective instructions “produce more self-related, and fewer target-related, thoughts than imagine-target instructions.” More globally, there was an indication that there is something inherent about Perspective-taking, as maintaining a control group that did no Perspective taking was difficult. This could indicate that taking another’s Perspective is a “natural” state for humans.

The relationship between Perspective taking and theory of mind is one area that has been examined a lot. Harwood and Farrar, 2006 [95] examined this relationship in 42 three to five year olds. In their experiment, each child performed three tasks, one to test affective perspective taking ability, one to test theory of mind understanding, and the last to test language development. They found a positive correlation between theory of mind skills and affective perspective taking skills, and the correlation was the strongest in the scenarios in which emotional conflict was involved. They indicated that having the ability to take another's Perspective is key to the development of empathy. This indicates that both perspective and theory of mind can be taught and influenced in social systems and development. The article states that the biggest link between the two concepts is that they both require the child to understand different or conflicting Perspectives.

Tversky and Hard, 2008 [96], asserted that having an egocentric Perspective is natural, which if looked at from an evolutionary Perspective, makes sense. The self comes first and anything else takes extra mental effort. Terms like front, back, left, and right are usually used in relation to the self's spatial position in the environment. However, sometimes taking another's perspective was necessary for survival. Socially, this occurs when someone asks for directions or the location of an object. In their two studies, when asking people to take spatial Perspectives (either their own, another's, or an object's) people naturally took their own when they were in the room alone. However when another person was introduced as part of the scene, they subconsciously switched to taking that person's spatial Perspective. "Given the difficulty of using right and left from one's own Perspective, reversing right and left to take another's Perspective is notable." They also offer, "It would be an interesting if surprising extension of embodied cognition if attitudinal or emotional perspective-taking also promoted spatial perspective-taking." This indicates that just the visual cue of another person is enough to trigger the use of Perspectives.

Wang et al 2014 [97] researched whether taking another's perspective increased intergroup contact with outgroup or stereotyped members of the group. They did 3 experiments, the first measured how close participants sat to members of an outgroup after going through a perspective-taking exercise. The 116 undergraduate students tested had to write a narrative essay about a person in a photograph (a young Asian man with spiky hair and tattoos). They manipulated the instructions so that there was a perspective-taking condition, a suppression condition, and two control conditions. The first control condition had the participants take an "objective focus" and the second control condition did not provide participants instructions at all. After they wrote the essay, the man in the photo was in another room that the participants were brought into. The distance the participants chose to sit from the man was measured. They found that the participants who went through the perspective-taking exercise (instead of the control) sat on average closer to the outgroup member than all the other groups.

The second experiment had 31 undergraduate students as participants. The set up was the same, except that instead of measuring how close they sat to the man in the photo, they measured their willingness to meet the man in the photo another time. Therefore, "perspective-taking tendencies were associated with greater willingness to engage in contact..." The third study tested if taking one outgroup members perspective led to a shifting perspective on the group itself. The 148 participants were shown a picture of a homeless man and were asked to write their essays on a day in his life. All conditions were the same as the first experiment. They were then asked how many additional activities (1-6) they were willing to participate in with another homeless man. Overall, they found that active perspective taking helped people interact with the entire outgroup more positively. This research showed that perspective-taking "increased individuals' willingness to engage in contact with stereotyped outgroup members." Overall, the body of research on perspective shows that the more aware one is of their own and the perspective of others leads to better communication, interrelations, increased empathy, and prosocial behavior.

Humans regularly engage in "prosocial behavior[17]" which is thought to be motivated by a feeling of empathy for others. The purpose of Ben-Ami Bartal et al.'s [73] research was to explore if rats would also engage in prosocial behavior if they had the opportunity. In their experiment, they placed a free rat into the test area which contained either an empty restrainer (for the control) or a rat trapped in the restrainer. The rats placed in the experimental setup worked hard to free the constrained rat, while the ones in the control did not attempt to open the restrainer. They then did an experiment to see if there was a stimulus that would encourage the rat to be selfish (anti-social) if it would change the behavior of the rats. The experimental arena was changed to include an additional restrainer which was full of chocolate. The rats worked to open both restrainers, and in most of the experiments, they shared the chocolate with the freed rat. This experiment shows that rats have the ability to take Perspective and have empathy for another of their species. Their Perspective taking ability leads them to do extra work in order to make another rat less miserable. The root of empathy is Perspective, which is fundamental to social organisms. Without it, we would not be able to coexist with one another. To increase empathy among us, we must start with building perspective taking skills, a fundamental element of systems thinking.

6. DSRP: Not Steps...Fractal, Recombinant, Recursive, Simple Rules

It is common, when first introduced to DSRP Theory to think of its four patterns (D, S, R, and P) as (a) descriptive "buckets" and/or (b) a stepwise list. They are not. DSRP Theory explicates universal structures that exist, but it also explicates the dynamics between the simple rules that lead to the emergence of those structures. This latter aspect of DSRP Theory—its dynamical prediction is often lost on the new reader. Nevertheless, the dynamics of the theory are, in many ways, far more important to understand. There are reasons why (a) and (b) are common.

First, DSRP as a way to post-hoc describe conceptual objects and "bucket" or categorize them is easy to do and perhaps a natural by-product of our love of and the comforting nature with finite categories. It is easy to say, "that is a Distinction, whereas here is a Perspective, and this is a Relationship." It works reasonably well and is easy to do. The problem is that these four cognitive patterns do not work in isolation, certainly not at the micro-cognitive scale (measured in time in nanoseconds or seconds). At the macro-scale, it is perhaps true that we can claim "This opinion is that man's perspective" and be reasonably accurate. But for something to be a perspective, it must exist. The existential nature of a thing has to do with the formation of it using Distinctions. Further, most things (conceptual or actual) are really conglomerations of things (ergo, they are Systems made up of parts). And, for those things to cohere as a thing, they must be related in some way, if nothing else that they are a coherent whole. If we randomly

[17] Social behavior that benefits another, or the community as a whole.

assign 10 things (people, buttons, data, chickens) to a group, we cannot assume that there exists any pre-group relationships between the things in the group. Yet, by virtue of them now being grouped, they are related as co-parts in the group and they each are related to the whole in that they belong to, or alternatively, are contained within the group. The group itself (the System made up of the thing-parts) is a Distinction, as are each of the things in it. Of course, none of this would be known to an outside observer who is not aware of the grouping, so these facts are also perspectival.

Second, DSRP is falsely thought of as a step-wise set of operations. This in large part may be due to the simple naming convention where the acronym DSRP falsely indicates an order of some kind. It may also be due to the human love and comfort with ordered, step-wise lists, especially attractive when the phenomena one is dealing with is as complex and convoluted as cognition itself. The elements of DSRP often work simultaneously and in no particular order. One could argue, for example that "D must come first" because it is existential in its nature. How can S, R, or P result from nothing? The truth is that Ds often come first and it is easy to think in this way. But, Ds also emerge as a result of the activities of the S, R and/or P rules. For example, there may be a number of similar items (they could be people, buttons, data, chickens, or mixed, etc.) presented to a subject.

Immediately, the human mind tries to make sense of the collection of items. They perhaps see that two people are wearing blue shirts, which causes them to see that another is wearing a blue hat and another blue socks. The initial recognition of blue shirts was an obvious relationship of similarity, blue becoming a Distinction that stands out from the other as-yet undifferentiated colors. But the blue-distinction quickly becomes a perspectival lens (is there a preponderance or pattern of blueness?) and the subject is scanning through the environment to identify blue (and by implication ignore not-blue). In doing so, they discover a blue hat and blue socks and they arrive at the grouping of "people wearing blue" and people not wearing blue." This grouping is a Systematization. But it is also a Distinction. And, relationally, it may cause the subject to say, "Are there people wearing red?" which through a similar process as described above may cause the person to conclude: Blue-group, Red-group, Other-group. This is merely an example, and the human mind is so adaptive, so plastic, so fluid, that one could easily imagine it taking a turn for a very different set of conclusions.

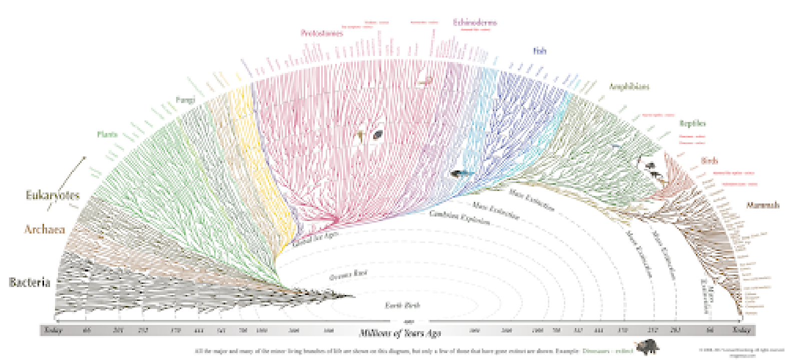
The point is that DSRP is not a step-wise or linear process. It is:

1. **Fractal**: DSRPs are occurring at multiple scales simultaneously. That is, while the informational content may vary greatly at different levels of scale, the underlying structure that underlies it is a self-similar and replicating pattern of DSRP.
2. **Recombinant**: The D,S,R, and P rules and their elements are massively recombinant. They are mixing and matching and producing different results. The rules are operating in parallel and constantly adapting and influencing one another.
3. **Recursive**: The output (results) of one iteration of DSRP (interacting with content information) can be utilized as an informational input for another DSRP iteration.
4. **Universal**: At a micro-level, D, S, R, and P cannot occur without D,S,R, and P. Indeed, inside each of the individual patterns, we see the structures of the alternative patterns being necessary for their existence.

Below we discuss a few studies that more explicitly show these dynamical dependencies. It is the massively parallel processing of these simple rules that provides for the type of complexity and adaptivity we actually see in cognitive processes while at the same time, borne of stunning simplicity. It is this simplicity that allows the mind not merely to use structures to describe what is or has been, but to use these same abstracted structural cognition to *predict and to be generative* because the structures themselves prompt the mind to ask structural questions.

In Form, Substance, and Difference by Gregorgy Bateson (1970) [98] he discusses Pythagorean's philosophy of looking at patterns rather than content. He then offers that the idea of the Mind was roped into early evolutionary theory, making pattern and mind two—seemingly simple, but incredibly powerful ideas. He also explores the concept of "difference", or in our case, Distinctions in which he wrote, "I suggest to you now, that the word 'idea', in its most elementary sense, is synonymous with 'difference'." This correlates well with the idea that every thought is within itself a *Distinction*. Bateson's combination of pattern and difference has contributed greatly to Systems science[18].

For the name of his book, Darwin chose, On the Origin of Species: by Means of Natural Selection, or The Preservation of Favoured Races in the Struggle for Life [99]. He used the term Origin of Species to describe his theory of evolution which describes how a new species (a.k.a., a group or organisms) is formed. Indeed, it could be said that whether or not two organisms share the same species, is largely a matter of how they relate to one another (i.e., whether or not they are capable of interbreeding or exchanging genes). This means that every unique identity formed by nature's evolutionary processes is globally connected to every other organism (other) in the creation of species groupings. If, as a hypothetical example, it was suddenly realized that a dolphin could mate successfully with a rabbit, their respective species classifications would be called into question. This means not only that every organism is genetically distinguished (identity-other) from every other organism, but also that every species (part-whole grouping of organisms) is genetically distinguished from every other species; and, vice versa, that every organism in a species is genetically related to every other organism in that species. This means, too, that nature itself is making these identity-other distinctions not only at the individual level (organism DNA) but also at the part-whole species level (species DNA).



[18]For some further reading on the universality of DSRP theory, I recommend How People Learn: Brain, Mind, Experience and School by Bransford, Brown, and Cocking which is an excellent book that consolidates cognitive science research on learning. Also, Mind and Nature by Gregory Bateson is another book that elaborates on Bateson's thoughts on the patterns that connect organisms to each other and their environment.

In “Origin,” Darwin describes the fundamental mechanisms involved (i.e., "descent with modification through natural selection" (p127, [99]) in how nature distinguishes new biological groups (i.e., part-whole systems). Nature not only distinguishes new organisms and part-whole systems of organisms called species, it also stops doing it, in a process called extinction. Recently, fish and game officials confirmed that 23 species [100], including the beloved ivory-billed woodpecker, had gone extinct. In other words, nature no longer makes these distinctions. Because scientists have not been able to locate any members of these species since the 1980s or more, it has been determined that these 23 part-whole systems of organisms (species) have ceased to exist including [100]:

- 11 bird species (Bachman's warbler (1988), Bridled white-eye (1983), Ivory-billed woodpecker (1944), Kauai akialoa (1969), Kauai nukupuu (1899), Kaua'I 'o'o (1987), Large Kauai thrush (1987), Maui akepa (1988), Maui nukupu'u (1996), Molokai creeper (1963), Po'ouli (2004));
- 1 bat species (Little Mariana fruit bat (1968));
- 8 mussel species (Southern acornshell (1973), Stirrupshell (1986), Tubercled-blossom pearly mussel (1969), Turgid-blossom pearly mussel (1972), Upland combshell (1980s), Yellow-blossom pearly mussel (1980s), Flat pigtoe (1984), Green-blossom pearly mussel (1982)); and
- 3 fish species (San Marcos gambusia (1983), Scioto madtom (1957), Phyllostegia glabra var. lanaiensis (1914)).

Interestingly, like the dodo bird (1662), the human mind still makes these since-lost distinctions, but nature has ceased to make them.

Bertalanffy (1972) [101] studied the historical significance and status of the General Systems Theory (GST). He discussed one of the first assertions made about Systems. “Aristotle's statement, “The whole is more than the sum of its parts,” is a definition of the basic system problem which is still valid.” He goes on to discuss the “Gailean conception,” which moved the world towards believing that the cosmos directed fate and decisions to viewing events as the result of reasonable, mathematical laws. Bertalanffy cited Descartes bete machine and Darwinian natural selection as the two ideas that helped deal with the problem of order within Systems theory. In relation to the part and the whole aspect of a system, he writes, “Hence an object (and in particular a system) is definable only by its cohesion in a broad sense, that is, the interactions of the component elements.” This paper highlights the importance of recognizing the parts, the whole, and the relationships between the parts.

Of equal importance at this time was the work by Rittel and Webber 1973 [102] in the field of planning, and demonstrated how systems thinking could be helpful in solving “wicked problems.” The perspective one uses to see problems has shifted from the problems being “definable, understandable, and consensual.” Wicked problems are characterized as; undefinable, have endless effects (some known and some unknown), there is usually no right answer to solve them, and they are incredibly hard to test. You cannot use trial and error to solve a wicked problem as the solution will have a great impact on the system. The recognition of wicked problems has led to the reexamination of national values and goals. This was done by shifting the Perspective one took on the Systems they worked with. Instead of looking at just the parts of the Systems, they were encouraged to look at the Systems from the view of “What do these systems do?”, and more importantly, “What should these systems do?” They needed to explicitly Distinguish what their desired outcome was, and how taking that Perspective would change the System. Explicating their outcomes led to a deeper awareness of the interconnections among parts of the Systems, and that awareness made it necessary to expand and work with the boundaries they had placed for that System. Thus, a deeper understanding of the Systems and wicked problems they face, leads to identifying the root causes of the problem in the first place.

The concept of a system is one of the most powerful and important ideas in science and the real world, and therefore, getting a general concept of systems is a high priority. Marchal, 1975 [103] explored the concept of a system. He explained that while the actual word "system" can have multiple meanings, the most important form of it is as a structural term. It can also be used in the form of an activity one does (i.e., doing something systematically). It's important to note that systems are "conceptualized differently by different investigators." In other words, the structure of a system will be different when looked at from different perspectives. Also, Marchal writes, "We certainly distinguish between, and are interested in, different kinds of systems, for example, nervous systems, number systems, and betting systems. The question is, do these distinctions between kinds of systems warrant, or require, parallel distinctions among senses of 'system', each with its correspondingly different concept of a system?"

Marchal is essentially drawing a line between Distinctions and Systems for us. One is able to turn a system into a distinction, and Marchal acknowledges later that systems are also made up of distinctions. "We can distinguish between things if some feature of one is not had by the other. The distinctions that we bother to draw rest on our interests." Importantly, Marchal's definition of a system is: "S is a system only if S is a set of related elements." Therefore, the word 'system' implies a set (S) of interconnected (R) components (D). It is important to note that Marchal is implying that the Relationships themselves are also to be counted as components of the system. This article excellently demonstrates the interconnections between the patterns of mind, as in order for one to Systematize, they have to Relate and make Distinctions.

Another paper that goes into the elements D, S, R, P, as a whole theory is Goguen and Varela 1979 [104]: Systems and Distinctions; Duality and Complementarity. They write in the introduction that, "It is evident that different people find it convenient to divide the world in different ways, and even one person will be interested in different systems at different times." This connects Distinctions (dividing the world is the same as Distinction-making), Systems, Relationships (the interconnections between them), and Perspectives (they clearly state that each person will have their own perspective on D, S, and R, and that the Perspectives can change depending on the context). In terms of Distinctions, they stated that distinctions are one of the most fundamental processes that humans do. They also noted that Distinctions work in tandem with Perspectives, with individuals making different Distinctions based on their intent, context, and individuality. They also wrote that, "The properties of a system emerge from the interactions of its components." Relationships are therefore another essential part of human thinking/being. They posit that a System can be part of another larger system, and that a System can be part of another even larger System, and so on. "There is no whole system without an interconnection of its parts; and there is no whole system without an environment. Such pairs are mutually interdependent: each defines the other."

Ivan et al 2001 [105] researched how cells are able to sense the levels of ambient oxygen in their environment and react to them, for which they were awarded the 2019 Nobel Prize in Medicine. Specific cellular processes like this one are an example of how Distinctions, Relationships, Perspectives, and Systems may not be merely a pattern of mind, but a pattern of life. Ivan et al. looked at how HIFs (hypoxia-inducible factors) are a factor that plays an essential role in cellular adaptations to oxygen changes in the environment. HIF binds to DNA to stabilize it in a hypoxic environment, leading to the expression of genes that promote processes like angiogenesis and glucose metabolism. Ivan et al. looked at the relationship between HIF and Von Hippel–Lindau (VHL) disease. VHL is a cancer that is characterized by the development of highly vascular tumors. The protein pVHL in humans is linked to a compound that regulates HIF. It binds with short HIF peptides when the core of the HIF peptide is hydroxylated and destroys it. This core is made up of prolines, which require oxygen and iron to become hydroxylated. Overall, the fact that non-neural entities such as cells are able to make distinctions is not necessarily the most remarkable thing about this discovery. What is remarkable is that every little system in the bodies of **all** species is based on the ability to perform the D, S, R, and P functions. Thus, the universality of the DSRP functions across all living organisms becomes apparent.

Chen explains that, “Bond breaking and forming are essential components of chemical reactions.” Bonds are synonymous with relationships. Atoms form Relationships with each other to create molecules. Chen et al. (2021) [106] explored the Relationships between molecules to find out the strength of these bonds. They used atomic force microscope tips to put mechanical force on the Relationships between atoms [106]. Chen explains, “The dative bond between carbon monoxide and ferrous phthalocyanine was ruptured via mechanical forces applied by atomic force microscope tips; the process was quantitatively measured and characterized both experimentally and via quantum-based simulations [106].“

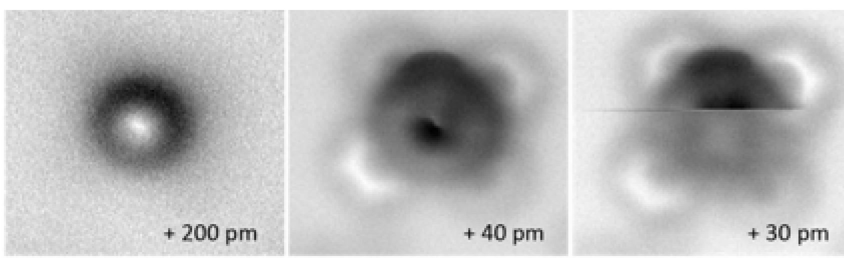


Figure 33: This image shows the relationship between the distance of the tip of the atomic force microscope tip and the breakage of the RDS [106].

Figure 33 contrasts the moment (+30pm) when the RDS is broken. In fact, Chen [106] explains that the relationship is well known (distinguished) and includes several parts (it is a system). “The dative CO-FePc bond is known to be formed via σ-donation from the CO 5σ orbital and π-back donation from Fe dπ [106–110]. ” Indeed, several research studies further explore what is referred to in DSRP Theory as an “RDS” (A Relationship-Distinction-System) [111].

This clearly includes non-neural organisms as well. Bacteria can respond to numerous stimuli in their environments from the concentrations of nutrients, toxins, oxygen levels, or pH, to osmolarity (the concentration of a solution), to the intensity and wavelength of light [112]. This response requires the organism to Distinguish between the different types of stimuli. A common response is movement, but chemical secretion and even gene expression [112] are also frequent responses. Chemotaxis benefits the cell, and the organism as a whole. For example, chemotaxis is at play in fetal development of the nervous system, tissue maintenance, tissue restoration and wound healing [113], as well as other processes such as pathogenicity (disease causing), symbiotic interactions, and the creation of biofilms. And, chemotaxis is critically important for the proper functioning of the immune system [113].

It is known in the scientific community that species of birds, insects, turtles and even lobsters, are able to use the Earth's magnetic field to navigate complex migrations [114]. However, the specific mechanism that these species use is still largely unknown. Ikeya and Woodward (2021) [115] advanced our understanding of this process when they explored the relationship between the Earth's magnetic field and cellular chemical reactions. Specifically, their hypothesis involved "radical pairs"—a radical is a molecule that has an odd number of electrons. When two radicals get close together, their electrons can get tangled, forming a radical pair [114]. The two become Related for a short period of time in the quantum realm [115]. Their Relationship can be in sync or as opposites, changing the speed of chemical reactions during the time they are related. To test this hypothesis, Ikeya and Woodward performed an experiment on human cervical cancer cells because they are both sensitive to magnetism and they glow. First, the researchers caused the cells to glow[19] and they then ran a magnet over the glowing cells. They observed that the presence of a magnetic field caused the fluorescence to dim by about 3.5% [115] because the Relationship between two molecules has an overall effect on the chemical reactions in a cell. More research is needed in this topic, but it is likely that this quantum Relationship is how animals navigate their migrations, and could impact biology as a whole.

Forster et al. [116] researched the neuronal pathways of hunting zebrafish. They used a technique called retinal axon projections to map out the neuronal perspective of the fish's visual environment. Through their analysis of the fish's hunting behavior they determined that posterior tectal neurons (which are responsible for detecting prey at a distance) responded mostly to smaller objects. Of interest is that those neurons appear to quickly and automatically Distinguish which direction the prey is at. This inherent Distinguishing ability allows the larval zebrafish to hunt effectively. This also further supports the evidence that the Distinction simple rule is inherently built into the organism's brains.

The factors of space, time and number are interrelated and hypothesized to be processed by a "common magnitude system" in the brain, specifically the parietal cortex [117]. De Corte et al. (2017) [117] conducted experiments on pigeons to test the veracity of the hypothesis that they can comprehend the Relationship between space, time and number. If they could, it is likely that other species can as well. For their experiment, De Corte et al. taught the birds how to judge either the temporal length or the spatial length of a horizontal line [117]. Interestingly, birds do not possess a cortex. After teaching the pigeons to Distinguish the difference between long and short times or distances, rewards were assigned to different conditions. For example, if a line was long, the bird had to press one button to get a food reward. If a line was short, the bird had to press another button to get the food reward. De Corte et al. wrote,
"...our results show that space–time interactions do indeed occur in birds and closely parallel those observed in monkeys...One possibility is that this system may not be cortically dependent. The striatum is shared between birds and mammals, and integrates diverse information, such as time and goal directed behavior [9]. Perhaps this structure also integrates time, space, and number (pg 2, [117])."
Their results demonstrate that pigeons are able to draw Relationships between space, time, and the interaction between the two, and have the potential to demonstrate that there are specific neurological structures that relate things.

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[19] The fluorescence is a result of radical pairs [115].

Jays think about how they store their food (known as a food caching). Two of the Perspectives that jays take when caching food are preference and perishability [118]. This means that jays choose food they prefer and collect food that remains edible longer. Schnell et al. writes,

> "To protect their caches from theft, jays employ a range of different cognitive tactics that limit the observer from obtaining visual or acoustic cues that might reveal the location of the store [5–7]. For example, jays preferentially cache in shaded sites or behind barriers to reduce the quality and transfer of visual information to potential thieves [8–10]. Jays also prefer to cache in quiet substrates to conceal auditory information, particularly when a competitor cannot see the cacher but is within earshot [11,12]. In instances where a competitor's sensory access cannot be reduced, cachers misdirect potential pilferers by making genuine caches in among multiple bluff caches, making it difficult for an observer to accurately trace the caching event [6] (pgs 1-2, [118])."

Jays also exhibit interesting behavior in the way they hide their food. When Jays look for the best hiding spot for food, they take the Perspectives of other jays [118] to determine how visible, 'stealable,' and safe their cache is.

Schnell et al. (2021) [118] showed that jays can understand simple cognitive 'illusions.' Three types of food were involved in their experiment; a favorite-food, a liked-food, and an undesirable-food. First, jays were shown liked-food as it was placed under a cup. Then, one of two conditions occurred—one where the jay's expectations were met (the liked food was under the cup) and the other where it was not—the food under the cup was different [118]. The jays in the first condition accepted the food, but the ones in the second condition took time to inspect the food.

> "The response pattern to the different conditions in the adapted cups-and-balls routine demonstrates that the birds were only sensitive to the value of the different food items in the manipulation conditions when the hidden items violated their expectations (pg 8, [118])."

That jays have an expectation that "X will follow Y" means they are drawing a relationship between X and Y. Their inspecting behavior indicates that the Relationships that lead to the jay's expectations were violated. This discovery that jays make Relationships, combined taking Perspectives, indicates that jays use various DSRP patterns to manage their food caches and to understand and react to cognitive 'illusions.'

Honey bees have a natural circadian rhythm based on daylight changes that they use to forage, by remembering the best time to search for food and its location [119]. Giannoni-Guzmán et al. (2021) [119] explored if temperature influences a bee's circadian rhythm when they measured the temperature inside hives and found that the internal temperature of a hive fluctuates in a seasonal pattern. They then changed the temperatures in the hive manually while exposing the hive to total darkness and found that the bees' used temperature as a signal in the same manner that they relied on daylight [119]. This experiment shows that bees Distinguish between light and dark, and also between hot and cold and then Relate both to optimal foraging times and social behaviors. In such simple behavior, we see that bees rely on the DSRP patterns to forage for food much like other organisms detailed in this chapter.

The process of categorization (forming distinctions between types of objects), begins at around 3 months of age, and improves as the infants grew according to Mareschal and Quinn, 2001 [120]. They completed

5 studies with infants between 3 and 30 months of age on their ability to categorize[20]. This was measured in five ways, from visual preference, object-examination, leg-kicking, generalized imitation, and sequential touching. The visual preference experiments were tested via a portable apparatus that provided a viewing chamber with a grey stage that contains two compartments, used to display two stimuli *simultaneously* to the infant.

The object examination experiments were conducted in two phases, familiarization and testing. In the familiarization phase, infants sat in a highchair and were given objects in a random order to simply gain some understanding of the objects prior to testing. The testing phase involved three trials of the presentation of: a novel instance from a familiar category, a novel instance from a novel category, and a completely novel stimulus.

There were three types of tests performed - the one that is of greatest interest is the sequential touching test. During the sequential touching experiments, infants were seated in highchairs and eight objects were randomly placed on the high chair table. The infant is allowed and able to independently manipulate the objects for several minutes. The order in which the infants manipulate the objects is observed and recorded. The results showed that "studies not requiring a familiarization phase find that infants separate entities according to broad, global category distinctions." While studies that did have a familiarization phase showed that, "infants can sort entities into global categories, but they can also form more finely tuned basic-level categories, and in some instances are even sensitive to the exemplar-specific characteristics of the individual instances presented during familiarization." Their research demonstrated that the Distinction making process begins early in life, and leads one to see that Distinction making is also an essential part of categorization. This indicates that in order to perform a task as simple as interacting with objects, both the D and S patterns of mind are present and could lead one to infer that these are fundamental processes in human thinking due to their early appearance in life.

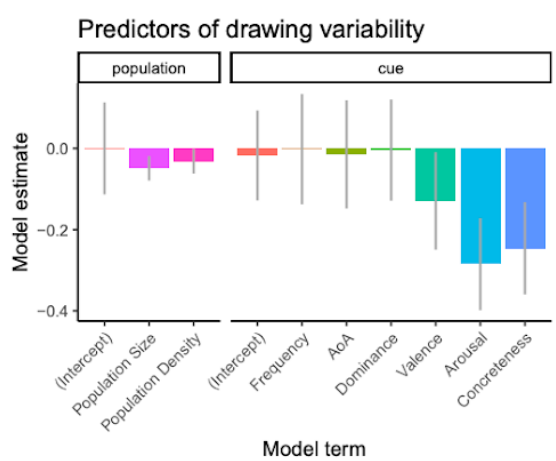
Ashby et al 2003 [121] discusses procedural learning within perceptual categorization. For the first experiment they did, "there were three experimental conditions: control, hand switch, and button switch. In all the conditions, the observers depressed the two response keys with their index fingers, and trial-by-trial feedback was provided." For the hand-switch condition, the observers began the first 500 trials with their hands crossed on the buttons, and for the button-switch condition, the buttons used to make the category response were reversed for the last 100 trials. For the second experiment, the procedures were the same as in the first experiment, except for the following: "Each participant in the unidimensional conditions completed 5 blocks of trials (with 50 trials per block), and the change in response instructions occurred after Block 3 for all the conditions. Each participant in the diagonal conditions completed 12 blocks of training (50 trials per block) during the first experimental session. The second session occurred approximately 24 hours later. The procedure during the second session was identical to that of the single sessions used in Experiment 1. Finally, the diagonal/ hand-switch condition was omitted." In discussing the two types of category structures, the article suggests that the formation of these category structures developed due to a survivalistic need for a quick response to the environment. Using examples like safe food and poisonous food, and the motor response of seeing a snake and then

[20] While categorization is a term more associated with part-whole Systems, it is also important to note that in order to categorize, one must not only see objects as groupable into part-whole structures but also make Distinctions between or among groups of types of objects.

jumping backwards, they showed that the categorization of objects and information developed through making distinctions and forming a physical relationship to them, resulted in categorization.

Sloutsky, 2003 [122] argued that perceptual and attentional mechanisms are the places where categorization is developed. This is due to the perceptual and attentional mechanisms ability to detect similarities in an environment. Sloutsky inferred that the more often one makes categories, or is put into situations where categorization is needed, the better and faster one gets at categorization. He concluded that categories are more easily facilitated by similarity-based relationships between objects, rather than a difference-based one. This is due to the natural impulse to use the parts of an object in order to determine what it is and in which category it belongs to. Sloutsky wrote, “For example, when 2- to 3-year-olds were asked to extend a learned word to novel instances, they attended to both shape and texture if the entities presented had eyes (presence of eyes is diagnostic for the animate–inanimate distinction), whereas when the same entities were presented without eyes, participants attended only to shape.” The use of parts to figure out where the whole object belongs requires not only Systems, but Distinctions and Relationships.

While there is value in understanding the ‘average’ person’s understanding of a concept, there is equal value in understanding the variability among people’s conceptual formation. Lewis et al. (2021) [123] did an analysis of millions of sketches from around the world. According to Lewis, drawings are used because, more so than words, drawings clearly show whether a group of people share the same meaning for a concept (for example, chair). “Drawings therefore provide an observable, quantifiable index of a person’s conceptual representations (e.g., Fan, Yamins, & Turk-Browne, 2018; Long, Fan, & Frank, 2018) [123].” Lewis, et. al. explored how to tell what a person’s mental model of a concept is going to be based on certain factors. They found that people who live in densely populated areas (such as a city) tend to have similar mental models about what a concept represents. Whereas people who live in less densely populated rural areas tend to have more varied mental models of the same concept. The factors that influence variability are shown in Figure 34 (below) [123].



The figure shows the population factors (population size and density) and cue factors (i.e., Factors that had to do with the prompt word itself. These were: chair, tree, bread, house and bird [123]). The notable ones are valence (Defined as,”pleasantness of a stimulus” (citation)) and arousal (Defined as, “intensity of emotion provoked by a stimulus" [123]), which provide the least variability. Another interesting result from their analysis shows that, "...two countries tend to have people with more similar conceptual representations when they are linguistically, geographically, and culturally similar [123]." Lewis' et. al. research illustrates that mental models for 'the same concept' not only differ but can also be shared among populations and cultures. This underlines the a priori (although not always accepted) idea that mental models exist, but also that diversity in mental models (across individuals and/or groups) engender a Perspective from which Distinctions are perceived differently including the Relationships and part-whole System structure that make up those diverse definitions.

Lewandowsky et. al. 2006 [124] discussed the concept of knowledge partitioning in relation to boundary conditions. They completed two experiments to test their hypothesis. In the first, 81 students volunteered for course credit. All of the stimuli and data recording was done on a computer. There was a training phase, in which 40 stimuli (shapes) were selected from random locations within the training space. They wrote that, "The two dimensions of the category space corresponded to the dimensions of the stimuli in each condition (e.g., height and width of a rectangle in the integral–verbal condition, and so on). Correct classification could be achieved on the basis of x and y alone." The training consisted of eight blocks of trials, each involving a randomized sequence of 40 training items. For the experiment the subjects had to categorize each stimulus, and later report on the rules they used to categorize.

For the second experiment, 38 volunteers were selected and given either course credit or $10. The procedure was essentially the same, with the difference being that the rectangles were presented with a counterclockwise rotation of 10º about the bottom left corner, and the dimensions of the boundaries were slightly changed. The results of the experiments led them to state that partitioned knowledge helps create the phenomenon where people make different decisions for the same problem in a different context. They noted that partitioning occurred most often in experts, as the more knowledge you have the more "parcels" you bring to the table. Through multiple experiments they determined that the more difficult and complex a problem is, the more likely partitioning is to occur. By distinguishing between aspects of the problem, people are able to use context to help solve complicated problems. Their work led them to believe that partitioning (aka, creating a boundary between two or more things) is a pervasive aspect of categorization (aka, grouping things according to their type or relationships), thus involving Distinctions and Systems.

The brain has two hemispheres: the right and the left. In a normal brain, the two hemispheres are constantly Relating to one another, sharing information through the corpus callosum [125]. What would happen if you severed this Relationship? Sperry (1961) [125] did just that. In his series of Nobel-prize winning experiments, he split the brains of multiple species (cats and monkeys) and observed them to see how they would react. The impetus for his studies was the medical observation at the time that severing the corpus callosum did not appear to have any significant neurological impairments in humans. Given that the corpus callosum was "the most massive by far of any single fiber tract in the brain," this was surprising to scientists [125].

In what are now called the "split brain experiments," Sperry split the brains of monkeys and cats along the corpus callosum. Through a series of extensive tests, his observations initially revealed that there was virtually no difference between the split brained test subjects and the normal ones. He wrote,

> "Callosum-sectioned cats and monkeys are virtually indistinguishable from their normal cagemates under most testing and training conditions… They perceive, learn, and remember much as normal animals do (pg 1749, [125])."

With more careful analysis however, Sperry discovered that if one isolates and tests the parts of the brain that correspond to each hemisphere, then you do begin to see differences in neurological performance.

> "...one finds that each of the divided hemispheres now has its independent mental sphere or cognitive system-that is, its own independent perceptual, learning, memory, and other mental processes (pg 1749, [125])."

For example, he found that if you cover one of the eyes of a cat with a split brain and then teach it visual cues, when you switch which eye is covered, the cat acts as if it had never learned any visual cues. The cognitive Systems are Distinct. The Relationships made in one System are not maintained in the other.

Lupyan, 2008 [126] completed three experiments that allowed him to observe a bridge between Distinctions and Systems. The first experiment involved 21 students searching for a non-letter within a group of similarly shaped letters. Lupyan wrote that the finding that is "significant is that the present finding cannot be attributed to a difference in novelty between target and non-targets – since the target was always novel – supporting the interpretation that such effects have more to do with greater processing efficiency of familiar stimuli." For the second experiment, 14 students (using the same stimuli as the first experiment) participated in a "speeded same/different judgement task." This experiment showed that "perceptual warping was **not**[21] the source of the conceptual grouping effect." The purpose of the third experiment was to examine "the impact of verbal category labels on visual search." The overall hypothesis was, "if conceptual categories affect visual processing online, then hearing a category name prior to the appearance of a search display may further modulate the degree to which visual representations are shaped by conceptual categories." 28 students had to identify a letter within a group of other letters. For some trials, the object they were searching for was labelled (named, distinguished), and for others it was not. He found that assigning a label significantly reduced search times. The overall result of his experiments was that the assignment of a label (or a Distinction) facilitated (Perspective) the grouping (Systemizing) and deeper understanding of concepts and ideas. Provided as a prime, the label (a Distinguished identity) is, in effect, used by the respondent as a framing Perspective to more quickly identify the identities that will be grouped.

Dijk et. al. 2008 [127] discussed embodied cognition, which is the idea that the brain is one part of cognition, while the body and the world are the other two parts of cognition. They wrote that, "Drawing on work in robotics, biology, and neuroscience, we propose a conceptualization (a metaphor) of the relationship between behavior, body, and brain activity in real-world contexts." One of the examples used to make their point was in robotics, as one builds a larger and more complex robot they need to focus heavily on how the bot processes the Relationship between its processor and the unpredictable environment it encounters. The article makes the point that, "the success of the brain's functioning is formulated in terms of how well it is able to model the outside world internally…" They imply that the Relationship between the brain and the outside world is essential to the brain's success. The sensory inputs of the brain and body all help D, S, R, and P to occur in embodied cognition.

[21] Emphasis added.

Mahon and Caramazza, 2009 [128], through their review of research from the intersection of concepts and categories, were interested in the organization and "functional architecture" of the brain, and used people with brain damage as their subjects to better understand this idea. They determined that concept organization in the brain is a multifaceted issue that reaches on many different regions of the brain. They went further to extrapolate that "human behavior arises due to the integration of multiple cognitive processes that individually operate over distinct types of knowledge." They also argued that our ability to organize concepts is grounded in the physical world. The importance of further research was highly emphasized, as they stated that, "progress in understanding the causes of category specificity in one region of the brain, or one functional component of a cognitive model, will require an understanding of how category specificity is realized throughout the whole brain and throughout the whole cognitive model."

Even non-living material such as water droplets are able to use a form of chemotaxis [129]. A Stanford biology and physics lab accidentally discovered odd behavior in droplets of water with food coloring in them. The droplets appeared to "sense" each other and would move in peculiar ways (Figure 31).

Figure 32: Droplet "choosing" behavior.

Governed by molecular physics, these droplets behave in a chemotaxis-esque way, exhibiting behavior where they "choose" similarly colored droplets or or "attract" or "chase" other droplets (Figure 32).

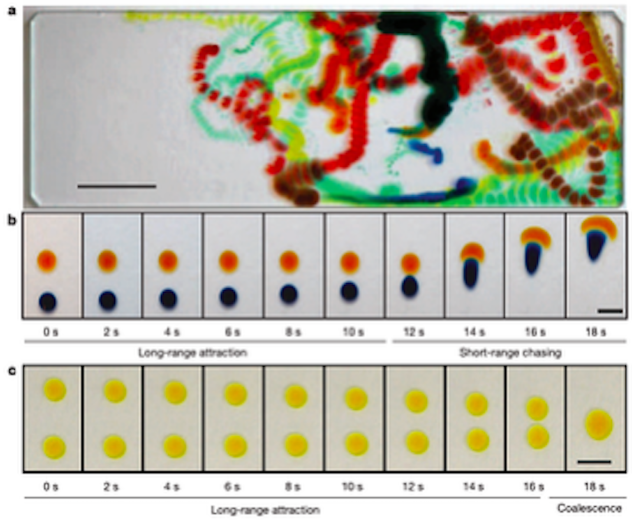


Figure 33: Droplet “chasing” and “attracting” behavior.

This occurs through various methods. For example, it occurs when droplets chemosense high or low energy and move accordingly across a gradient of surface energy. These water droplets are Distinguishing between the other droplets to Perspectivaly organize themselves into larger droplets.

Cells would not be able to navigate complex areas or long distances without self-regulated chemotaxis [130]. That is, cells can generate their own local gradients of chemicals, allowing them to react and adapt faster to a changing environment.

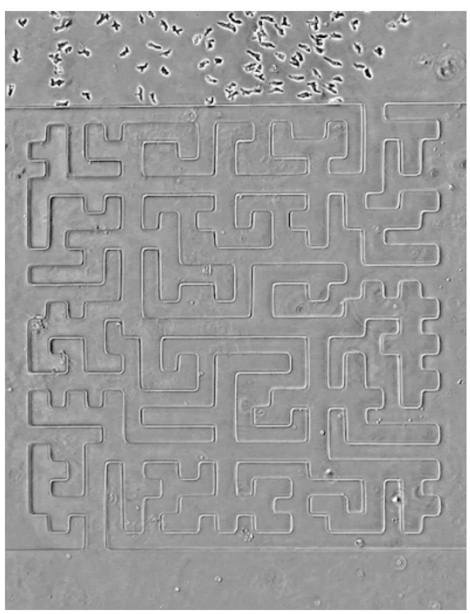


Figure 37: Example of cells solving a maze.
Credit: Luke Tweedy and Michele Zagnoni

To test how well a cell can move around and maneuver itself, Tweedy et al. [130] ran both amoebas and cancer cells through mazes to see if they could solve them. When both types of non-neuronal cells were placed in mazes of varying complexity, they were able to solve them. In many cases, the cells were able to identify the optimal path [130]. These cells possess the ability to make Distinctions between areas of high and low concentration to find their way to the end of the mazes.

Cells also work together as part-whole systems to find optimal paths through the maze.
"Cells broke down attractants locally, which were replenished at different, predictable rates by each possible path. The resulting local attractant gradients allowed cells to sense upcoming maze junctions before reaching them, even around corners, and to make correct decisions about paths they had not yet encountered. Attractant breakdown thus allowed cells to create a detailed picture of their surroundings [130]."

Cells distinguish previous paths taken by the cells in front of them, sensing the gradients of chemicals at key junctions in the maze, causing the success of one cell to lead to the success of others. This research shows that non-neuronal cells possess a limited but unique perspective from which they are able to make distinctions and organize their environment into part-whole systems to navigate through their worlds.

Additionally, when frog embryo cells are removed from the embryo and left on their own, they grow into mobile "balls" (xenobots) that can move and interact with their environment [131]. Lament et al. (2021) [131] wrote,

> The biological robots arise by cellular self-organization and do not require scaffolds or microprinting; the amphibian cells are highly amenable to surgical, genetic, chemical, and optical stimulation during the self-assembly process. We show that the xenobots can navigate aqueous environments in diverse ways, heal after damage, and show emergent group behaviors [131].

The individual cells "self-organize" into balls. The parts become a larger, functional whole that is able to react to different aspects of its environment. Not only that, but the xenobots are able to navigate different environments through Distinguishing the desirable molecular compounds they need to mobilize themselves. Finally, the xenobots are able to use the Relationship and Systems rules to interact and behave as groups. Overall, this shows how pervasive the DSRP patterns are, even small blobs of cells can use the rules to navigate their environment.

Tarrant et. al. 2012 [132] began by stating that Perspective-taking as a conflict resolution tool isn't always the most effective tool as it can lead to more animosity within the group. This is due to the relationship between group identity and perspective-taking. They did two experiments to test their ideas. In the first experiment, a group of participants (college students) were prompted to establish their in-group status, while another group was asked to read a paragraph and determine which group the subject of the paragraph is in. " Participants in the perspective-taking condition attributed significantly more negative traits to the out-group as in-group identification increased." In the second experiment, the in-group/out-group status was based on nationality. The idea was that if you increase the directness and the personal level of the grouping, that it would help to test the causal and robustness of the effect discovered in the first experiment. The results were that when one is more directly connected to the in-group, the out-group can be seen more negatively. When a Perspective-taking exercise is done in a group consisting of an ingroup and an outgroup, if a member of the ingroup takes another's perspective, they can be rejected or alienated from the ingroup as a result. This is due to the level of identification one has within the ingroup, the more dedicated they are the more negatively they react to the other and the exercise, as they can perceive that their identity is being threatened. A solution for this is to include in the exercise a discussion of not only Perspectives, but also Distinctions, Systems, and Relationships.

Dogs have co-evolved with humans over thousands of years. It should not come as a surprise that dogs are able to take a human's perspective and share many of the same emotions. It's well established that if a human gives a dog a cue via pointing, the dog is able to take the human's perspective and respond to the cue accordingly [133]. Takaoka et al. [134] researched if a dog would follow the pointing cue of a human who had a pattern of incorrectly leading the dog. Their experiment had three phases. In the first phase, the dogs were shown two cups, one of which had a food reward in it. The experimenter pointed the dog towards the reward cup. In the second phase, the dogs were shown what each cup contained, and then the experimenter pointed the dog towards the empty cup. In the third and final stage, stage 1 was replicated, and amazingly, fewer dogs followed the experimenter's cue in Stage 3 compared to Stage 1.

To ensure that the dogs were not just bored or fatigued from the task, they replicated the experiment, with the only change being that a different human pointed for the dogs in Stage 3. The dogs followed the new experimenter's pointing directions just as much as they did in the first phase. Takaoka et al. writes,

> "This research represents a step forward in understanding dogs' ability to infer human traits based on their prior experience with the humans… Here, we showed that dogs drew an inference about the reliability of the misleading human and used this inference to change their response to the informant. (pg 481, [134])"

Not only can dogs take the spatial Perspective of humans, they can Distinguish between reliable and unreliable humans, and infer Relationships that cause them to follow or disregard their directives.

Havy and Waxman, 2016 [135], did two experiments with 32 and 16 healthy nine month old infants. The general idea was that, "if infants formed two distinct categories during the learning phase, each linked to one (or the other) pole of the underlying distribution, then infants would detect that members of one category move to the right doors and members of the other category to the left." In the first experiment, 32 healthy 9 month old infants were randomly assigned to either the one-name or two-name groups. The stimuli were a spectrum of colorful creature-esque objects going from one creature to the other. One group was shown the objects, and a nonsense name was spoken (the one-name-group), while the other group was shown the objects and the two objects on the ends of the spectrum were each given a different nonsense name (the two-name-group). This resulted in the two-name-group sorting the objects based on which end of the spectrum they resembled most, while the one-name-group did not sort. In the second experiment, 16 healthy, 9-month-old infants were given similar stimuli (with the distribution tighter around the poles) and performed the same procedure as the first experiment. The researchers found that, "even when presented with a unimodal distribution, infants listening to two distinct names for exemplars at each end of the continuum formed two distinct categories." Overall, they determined that "even before infants begin to produce words on their own, naming serves as a strong supervisory signal for category learning, supporting infants as they impose boundaries along a continuum and highlighting the categories joints." This implies that the addition of Distinctions i.e., naming) to the Systems (i.e., categories) the infants are trying to make aids in their forming part-whole systems and even can begin their comprehension of Relationships.

The Marshmallow Test is a famous psychological test that was developed by Walter Mischel in the 1960s [136]. It tests how much self control a young child has by setting up a simple choice. The child can have one marshmallow now, or two in 15-20 minutes. The children that chose to wait generally had better self control throughout their lives. This ability to delay gratification is also shared by a very few animals. “The ability to delay gratification not only varies within but also across taxa. For example, relative degrees of self-control are typically higher in non-human great apes (henceforth apes), corvids and parrots [137].” This list now includes cuttlefish, as Schnell et al. has discovered.

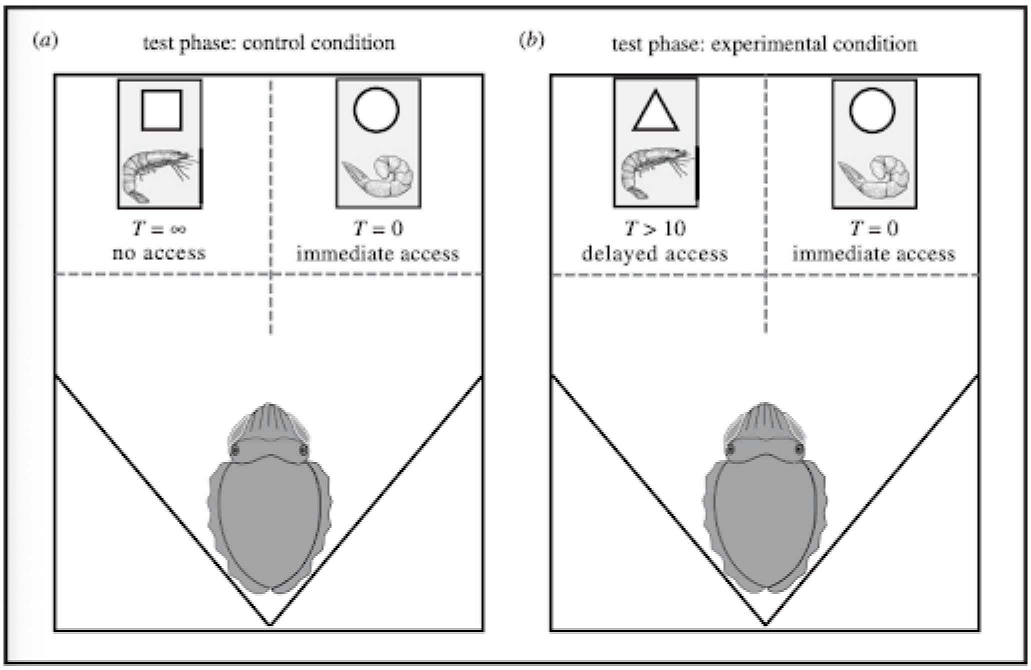


Figure 38: Cuttlefish experimental apparatus [137].

Schnell et al. (2021) [137] created an apparatus (see above) that would hold two different types of prey (one more desirable than the other). The doors in the apparatus were transparent so the cuttlefish could see what food was inside the boxes. They were trained to understand three symbols which were on the doors:

- Circle: Cuttlefish gets food right away;
- Triangle: Cuttlefish gets food in 10-130 seconds; and
- Infinity symbol: Cuttlefish does not get the food.

The researchers baited the no-delay box with the cuttlefish’s least preferred prey (raw king prawn), while the delay or no rewards boxes always had the preferred prey (live grass shrimp). After enough training sessions to ensure the cuttlefish built the correct Relationships between the amount of delay and the symbols, they ran their experiment. They ran each cuttlefish through a control trial and multiple experimental trials with delay ranging from 10 seconds to 130 seconds. At any point in the experiment, the cuttlefish could eat the least preferred food. Schnell et al. wrote, “Cuttlefish delayed gratification when it led to a prey item of higher quality and they were able to maintain delays for periods of up to 50–130 s (pg 5, [137]).” The cuttlefish were able to draw two key Relationships:

1. The Relationship between the symbol and the wait time; and

2. The Relationship between a delay of time and obtaining better food.

Schnell et al., found that "...cuttlefish in the current study, like primates [85], corvids [67,86] and parrots [87], show a positive relationship between both learning phases of the reversal-learning task [137]." They further state that there is a relationship between the symbol (learnt), waiting time (delay) and the type of food reward given, "This type of pattern suggests that the subjects are inhibiting previously learnt associations and applying a win-stay-lose-shift rule (i.e. choosing the response that was previously rewarded but shifting to the other response when original responses are no longer rewarded) (pg 7 [137])."

In summary, 'passing' the Marshmallow Test appears to be a good indicator of an organism's ability to draw complex Relationships. Cuttlefish have joined the ranks of the species able to exhibit self control and draw these crucial Relationships.

Boisseau et al. 2016 [138] investigated learning in non-neural organisms (i.e., a slime mold). A slime mold may not jump to mind as the ideal subject for research on the fundamental mechanisms of learning, however, Boisseau et al. states that maybe it should be. They define learning as "a change in behaviour evoked by experience." In their research with the slime mold (Physarum polycephalum), they found that it developed habituation behaviour, an "unmistakable form of learning." In their experiment, they exposed the mold to a stimulus (quinine or caffeine) and waited to see a response behavior (in this case, it was chemotaxis or movement based on a concentration of a substance). What they observed was remarkable. The more times they exposed the slime mold to the stimulus, its response rate was less and less. Eventually, the mold learned to ignore the stimulus altogether. When given a break from the stimulus and then reintroduced, the process started over again. These results open up a whole new world to the study of learning, as non-neural organisms have not typically been the focus for cognitive investigations which tend to focus on organisms with neurons and brains. What does it mean if learning can occur without neurons or brains? There are many implications. Of importance, this discovery shifts when the scientific community thought learning evolved, bringing the time much earlier than previously assumed. Second, this means that learning as a process is so fundamental to life itself that neurons, while helpful, aren't necessary to make distinctions (i.e., stimulus from non stimulus) and to make something as complex as a perspectival shift (i.e., "stimulus is bad and warrants a reaction" to "stimulus is neutral and can be ignored"). The point of this and many other similar researches into unicellular and multicellular organisms, plants, etc, is that even non-neural organisms can learn and are building little mental models of their surroundings (however rudimentary) based on distinctions, systems, relationships, and perspectives.

In Cabrera & Cabrera 2015 [139], the argument was that DSRP "offers a unifying and organizing principle for the field of systems thinking and an indispensable analytical tool for solving complex problems." In addition to that, they argued that while DSRP is academically useful and pertinent to problem solving, the theory also has significant social and psychological implications. Examples of this are in self-awareness, empathy, and decreasing negative social practices such as stereotyping.

This review of the literature has demonstrated that Distinctions, Systems, Relationships, and Perspectives have been and remain fundamental aspects of cognition, and interest in them spans many disciplines and domains. Furthermore, it is interesting to note, that while there is substantial research into distinction-making, part-whole thinking, relationship based thought, and perspective taking individually as cognitive acts, there is also some substantial research between and among them in human cognition, psychology, and neuroscience. Fundamentally, this review has positioned Systems Thinking within multiple domains, and especially centered it within the brain-based sciences. This is essential for not only the field, but for any future research that needs to be done in the field of Systems Thinking.

7. Conclusion

A: Systems Thinking is a Cognitive Science

Systems thinking is a quality of thought that exists in the real world. It is thought that is richer, robust, and contextually aware. Qualitatively, one can experience and identify the difference between thought that is overly simplistic, needlessly reductionistic, and contextually unaware; and that which is robust, rich, complex, and systemic. It is important to state this upfront as it is sometimes the case that the "map becomes the territory." Systems Thinking is also a field of academic research, but that field is the map, not the territory.

Systems Thinking is a style of thinking that attempts to incorporate "that which is known about how systems generally work." Systems thinking creates new knowledge about a given system and also attempts to uncover biases lead to unintended consequences, failure to see webs of causality, confirmation bias, delay, and exponential effects. Systems Thinking describes or elucidates new awareness of *the processes that underlie our thinking about systems* of various kinds.

At its core, systems thinking is a cognitive science that explores how "thinking can best be understood in terms of representational structures in the mind and computational procedures that operate on those structures."(95) There are three parts of this idea that are of importance. First, that thinking involves "representational *structures*" [emphasis added]. Second, that there are "computational procedures that operate on those *structures*" [emphasis added]. Third, that the structures are "representational" [emphasis added] which implies that their utility is born of their representational veracity (representational of what? The real world). Herein, we explore the structures that are universal to all types of thinking and the dynamical processes that operate upon these structures to evolve and adapt one's thinking.

B: DSRP Are Not Steps In a List, But Simple Rules of Complex Cognition

Thus, the process of thinking consisted of *structures and dynamics among them*. These representational structures are important to concept formation, knowledge creation, and the evolution of new knowledge, as part of memory, reasoning, logic, problem solving, language use, decision making, and all other cognitive functions. This also holds true for both emotion (feelings) and conation (motivation).

In layman's terms, cognition is often called "thinking." Metacognition, a subfield of cognition, is therefore referred to as "thinking about thinking" or "awareness of one's thinking." Because thinking is so essential to everyday life, it is important to consider both the scientific advances (theory and research) about cognition and it's practical applications (practice). In practice, there are numerous terms used to describe different types of thinking: critical thinking, analytical thinking, creative thinking, design thinking, interdisciplinary thinking, scientific thinking, and enterprise thinking. Other terms refer to *styles* of thinking (even if they do not include the term thinking) such as emotional intelligence, prosocial behavior, etc. These terms create labels for versions of thinking which are robust, adaptive, coherent, or generally speaking, better in specific contexts.

The term systems thinking encompasses all of these other types of thinking because it accounts for all of the systemic properties of the phenomena under observation, including the observer. Thus, if thinking is the popular term for cognition, then systems thinking is the popular term for complex cognition—cognition that goes beyond the standard thinking in a way that is better, more robust, adaptive, useful, etc. As such, systems thinking is the purposeful act of applying a systems lens to any topic of interest. The process of thinking systemically leads to an awareness of one's thinking—or *meta*cognition. Thus, systems thinking can be thought of as being synonymous with *complex metacognition*.

A *portmanteau* of "systems" and "thinking," Systems Thinking can be thought of as a "systems lens applied to all thinking." It is a method of thinking that:

1. Takes into account a wider set of variables (or "context") than is the norm;
2. Attempts to balance reductionism and holism;
3. Uncovers bias and assumptions;
4. Deals with more complexity well; and,
5. Aspires to be more complete or comprehensive than other types of thinking.

Thus the result of Systems Thinking is an awareness of norms and the aspiration to think beyond norms, while also taking them into account. Systems Thinking is therefore not only inherently *cognitive*, but also *metacognitive* (i.e., having to do with meta-states of awareness of one's thinking).

C: DSRP Exists in Mind and Nature and DSRP are Universal Cognitive Structures

This chapter articulates and explores the universal elements underlying complex cognition and metacognition. A review of the literature related to the four simple rules of cognition yields a wide set of peer reviewed articles, experiments and research that show these structures of thought exist in both the real world (nature) and in our thinking (Mind). We further see the elemental pairs that make up each of the four simple rules of cognition—making Distinctions (i,o), organizing ideas into Systems (p,w), recognizing Relationships (a,r), and taking Perspectives (ρ, v). Importantly, it is particularly important that we are aware of these structural elements of how we think. This awareness, ultimately, empowers us to deconstruct and deeply understand any concepts, issues, or situations involved in the challenges we face.

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