Distinctions Organize Information in Mind and Nature: Empirical Findings of Identity–Other Distinctions (D) in Cognitive and Material Complexity

Derek Cabrera [1,2,*,†] , Laura Cabrera [1,2,†] and Elena Cabrera [2,†]

1   Jeb E. Brooks School of Public Policy, Cornell Institute for Public Affairs, SC Johnson College of Business, Cornell University, Ithaca, NY 14850, USA; lac19@cornell.edu
2   Cabrera Research Lab, Ithaca, NY 14850, USA; eac272@cornell.edu
*   Correspondence: cabrera@cornell.edu
†   Authors contributed equally to this work.

Abstract: The transdisciplinary importance of distinctions is well-established as foundational to such diverse phenomena as recognition, identification, individual and social identity, marginalization, externalities, boundaries, concept formation, etc., and synonymous general ideas, such as thingness, concepts, nodes, objects, etc. Cabrera provides a formal description of and predictions for *identity–other distinctions* (D) or "D-rule" as one of four universals for the organization of information that is foundational to systems and systems thinking, as well as the consilience of knowledge. This paper presents seven empirical studies in which (unless otherwise noted) software was used to create an experiment for subjects to complete a task and/or answer a question. The samples varied for each study (ranging from $N = 407$ to $N = 34{,}398$) and were generalizable to a normal distribution of the US population. These studies support—with *high statistical significance*—the predictions made by DSRP theory regarding *identity–other distinctions* including its: universality as an observable phenomenon in both mind (cognitive complexity) and nature (ontological complexity) (i.e., parallelism); internal structures and dynamics; mutual dependencies on other universals (i.e., relationships, systems, and perspectives); role in structural predictions; and efficacy as a metacognitive skill. In conclusion, these data suggest the observable and empirical existence, universality, efficacy, and parallelism (between cognitive and ontological complexity) of *identity–other distinctions* (D).

Keywords: distinctions; identity–other; boundaries; universals; cognitive complexity; systems thinking; DSRP theory; ontological complexity; systems science

1. Introduction

Making distinctions between and among ideas or objects is an activity that crosses all disciplines. The concept of distinctions goes by many names including related terms and synonyms, such as: distinguish, differentiate, name, label, is, is not, identity, recognize, identify, exist, existential, other, boundary, select, equals, does not equal, similar, different, same, opposite, us/them, thing, unit, not-thing, something, nothing, element, and the prefix a- (as in a-gnostic or a-political). Any time we do any of the things we are making a distinction. That is, we are bringing something into existence conceptually or recognizing something exists materially and we always do so by relating identity and other. In this sense a distinction is not a "thing" its a boundary between what something is (identity) and what it is not (other).

1.1. Empirical Findings of Distinctions Across the Disciplines

The ecology of four studies documented in this paper exist in the context of the much wider literature of empirical studies and literature reviews on distinctions. An abundance of literature and empirical findings exists—across the disciplinary spectrum (i.e., the physical,

natural, social, and applied sciences)—for distinctions (D). Distinction making and boundary judgments are well established, both in the cognitive sciences and the field of systems thinking [1–35]. The literature on distinctions making (in the cognitive sciences as well as the physical and natural sciences) supports the idea that they are universally existent [2–5,7–9].

In a review of the literature, empirical studies illustrate both the universality of identity–other distinctions across the disciplines [1–9,11–20,22–39] and that distinctions are integrated with other universals (systems, relationships, perspectives) [21,40–72]. Figure 1 shows the disciplinary distribution of this research.
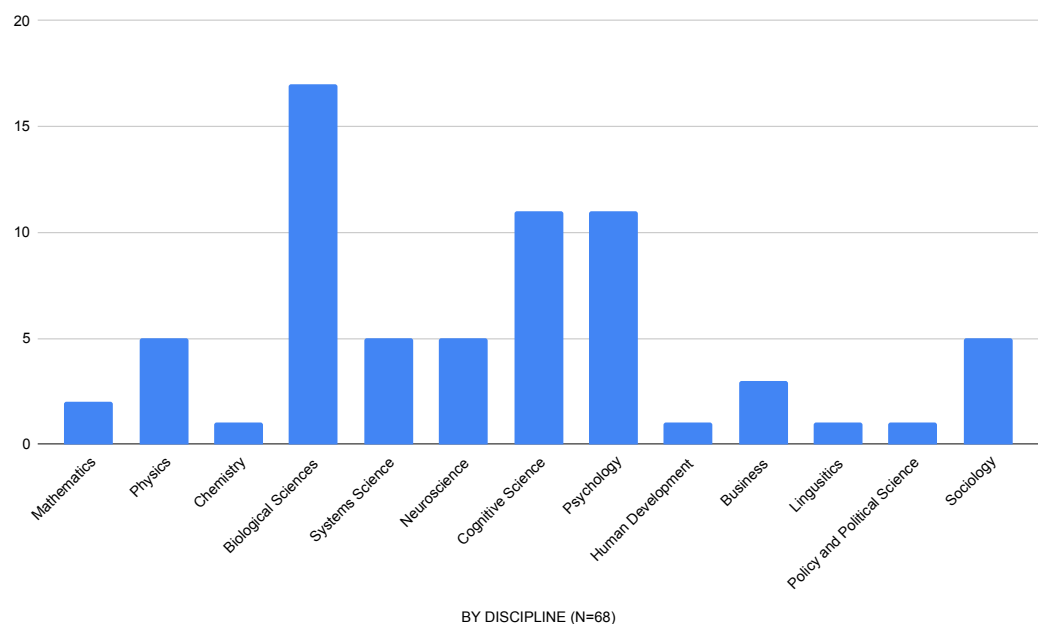

BY DISCIPLINE (N=68)

Figure 1. Identity–Other distinctions (D) Research Across the Disciplines.

Cabrera's 2021 review of research builds upon previous literature reviews [73,74], constitutes a proverbial "tip of the iceberg", and is part of an accumulating body of evidence in support of the predictions made by DSRP theory generally, and identity–other distinctions in particular. The findings, utility, and application of identity–other distinctions (D) are pervasive and ubiquitous. A few highlights from this literature review include:

- Kolata (1984) [4] shows that infants can distinguish their mother's voices as soon as they are born, indicating that fetuses make distinctions in utero;
- Aubin and Jouventin's (1998) [9] research the cocktail party effect in King Penguin colonies, showing that chicks only distinguish and react to their parent's calls and vice versa;
- Quinn et al.'s 1997 study [6] shows that, from an early age, the human brain distinguishes between different patterns and shapes, even if the two shapes overlap;
- Gautheir and Tarr's 1997 study [8], using computer-generated 'Greebles', demonstrated that the more exposure one has to fine-tuned and novel distinctions, the better they will be at recognizing them;
- Pradel et al.'s 2007 study [16] shows that nematodes distinguish their environments to avoid dangerous pathogens; and
- Langer et al.'s 1985 research [30] shows 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.

1.2. Theoretical Work on Distinctions

The simplest relatively accurate statement of the DSRP theory is shown in Figure 2:

"the   ways   information   is/is   not   bounded,   arranged,

and   interconnected   from   frames of reference   determines

what actually exists and what we think exists."

Figure 2. Simplest Accurate Statement of DSRP Theory [75].

The DSRP theory details quite a bit more than this simplification relays [73,74,76–79]. In addition, the DSRP theory has more empirical evidence supporting it than any existing systems theory (including frameworks, which are not theories) [73,75,80–88]. For more on the DSRP theory, the reader should see the citations mentioned, as this paper focuses solely on the 'D' in DSRP: distinctions.

As one of four DSRP rules, identity–other distinctions or the D-rule is applicable across the disciplines, from the physical and natural sciences to the social sciences. Their transdisciplinary importance cannot be overstated. For example, distinction-making (D) is defined as the act of differentiating among ideas or things; making a concept, construct, or thing explicit by delineating the "identity" that implicitly establishes an "other" (that are themselves concept(s), construct(s), or thing(s). Distinction-making is evident in the womb and is seen as early as three months of age. Experiments with adults also show the variety of ways that distinctions are made across a 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); and
3. That the relationship (i.e. is/is not) between *identity* and *other* is elemental in both (1) and (2) above.

Boundaries Are A Subset of Distinctions

Less clear however, is the underlying structure and dynamics of distinctions or the breadth of its application. In systems thinking literature, for example, boundary judgments (a phenomenon that is a subset of distinction making) were originally described as indicating "what information is considered relevant and what is considered superfluous, and are the result of value judgments" [34,89]. The 'flavor' of the concept of boundary judgment is important because it clarifies how it differs from identity–other distinctions. The boundary judgment is for 'the system' to determine what lays inside and outside of it, as seen on the left side of Figure 3. Cabrera [21,73,74,90–95] *expanded* the domain (see right side Figure 3) of these boundary judgments by demonstrating that they were not reserved merely for the single boundary of 'the system,' but were structural features occurring on fractal dimensions on every element inside (and outside) the system. Thereby predicting that:

1. All boundary judgments are *subsets* of identity–other distinctions;
2. All externalities identified by boundary judgements are *subsets* of *other*; and
3. All distinctions have an identity–other structure.

This critical insight—part of DSRP theory—exposed the universality and fractal-nature of identity–other distinction-making at the theoretical level. This ecology of studies empirically quantifies this theoretical construct.

Figure 3 illustrates the differences (shown in red) between boundaries as they were historically understood and identity–other distinctions as they are understood today. The image of the 'Boundaries Concept' on the left in Figure 3 illustrates that there is only one boundary (in red) for the system as a whole.
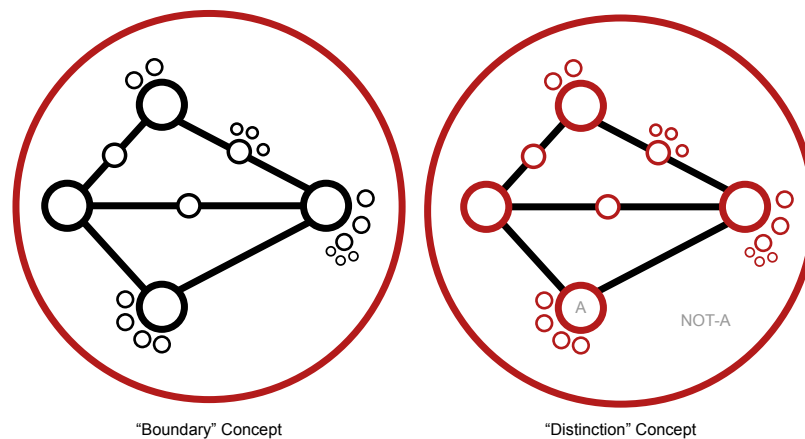
Figure 3. Boundaries concept vs. identity–other distinctions concept.

The image on the right in Figure 3 illustrates (in red) that every node in the network is a distinct boundary. It shows that the identity of *A* is defined not only by what *A* *is* but also by what *A* *is* not. Thus, the relationship between *A* and ¬*A* is defined by is/is-not and *A* co-implies ¬*A* as seen in Figure 4.
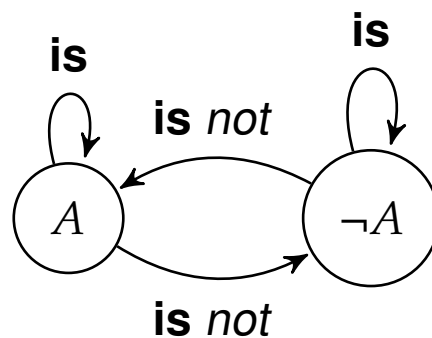

Figure 4. An identity (*i*) other (*o*) distinction (*D*).

This difference matters, because DSRP theory predicts that an identity–other network of *is* (existential identity) and *is not* (existential negation) relationships creates a cognitive 'dark matter.' In addition, it means that in any simple or complex system, network, or ecology (of things or ideas) of *n* nodes, the number of variables increases by 2*n* by implication. That is, for every D_o^i node (*identity* variable), there is an *other* variable, such that, for example:

$$\text{if } n = 4$$
$$\text{then } 2n = 2(4) = 8 \tag{1}$$
$$\text{where } 8 = 4 \text{ } identities + 4 \text{ } others = 4 \text{ } distinctions$$

This is shown in Figure 5 where the *identities* CAT, DOG, RABBIT, and GERBIL are distinguished from their *others* (¬CAT, ¬DOG, ¬RABBIT, and ¬GERBIL) and where it is shown that the *others* are part–whole sets.
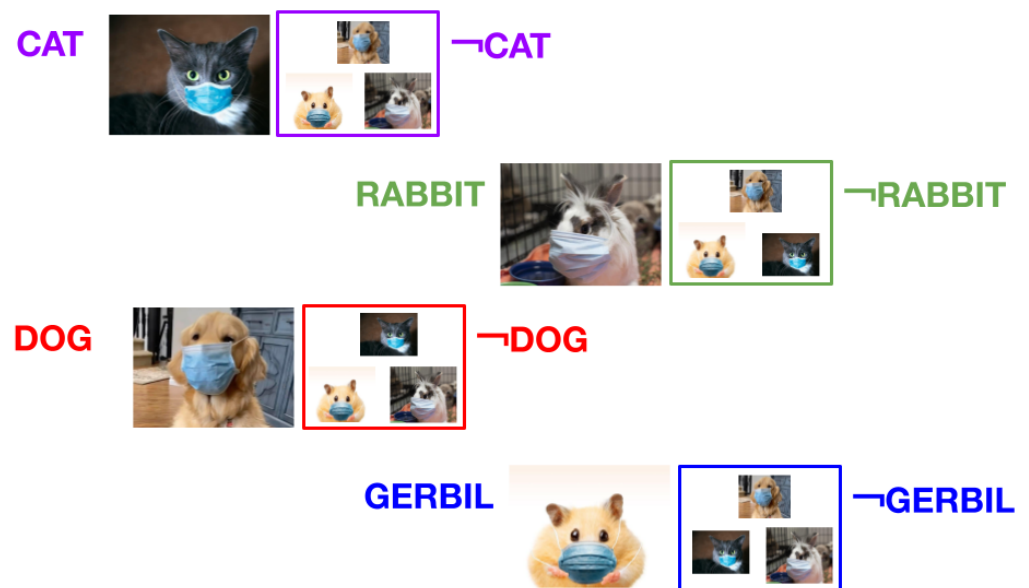
Figure 5. Four identities and their four other sets.

As shown in Figure 6, the relationship between identity and other is easily illustrated by the Ebbinghaus illusion or "Titchener circles". It 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.*
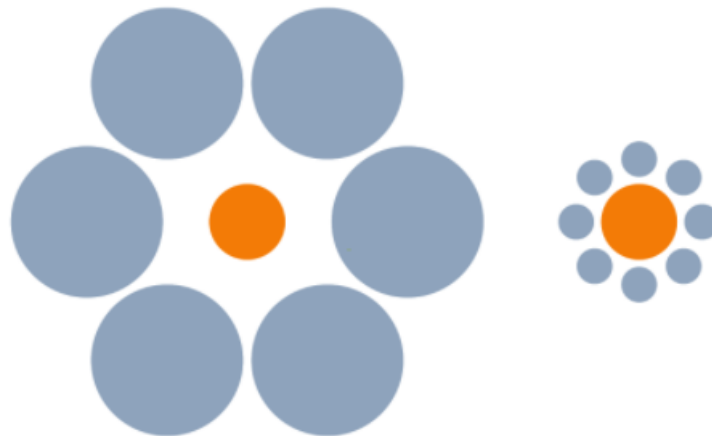

Figure 6. The two orange dots are the same size, but their 'context' makes them look like they are different sizes.

Similar to 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* (literally *together with text*). Yet, this context is not an amorphous cloud of meaning generating either. The context itself is just more text. This can be seen in the imaginary text passages below in Table 1. In this example, blue is the text being defined (i.e., the *identity*) and 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 1, you see a specific example using a homonym "rose", which can have different meanings depending on its context.

Table 1. Example of identity and other in textual 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 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.
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.

Indeed, by analyzing the relationship between *text* and *context* (in a literary sense), it gives us a better understanding of what we mean when using the term *context* beyond the literary domain. It is often said that, "it depends on the context". However, what we see here is simply that context is not some mysterious cloud that surrounds a thing. Context is the *other* things: other text, other people, other organisms, other things in the environment, etc.

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 did not exist. By recognizing me, you brought me into existence" [96]. 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 olfactorily. 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.

The theoretical construct of identity–other distinctions (D) is not merely accounting for all the identities and others that take place in mind and nature. Instead, it pushes our theoretical boundary from the *bivalent* to the *multivalent*; from the *static* to the *dynamical*. In doing so, it treads not merely on synthetic and analytical realms, but seeps into the *ethical*. Recognizing that an other exists whenever an identity forms—a theoretical prediction of the DSRP theory—is part and parcel of ethical behavior and the prosocial perspective taking that undergirds compassion and empathy for others.

Indeed, identity–other distinctions (D) theoretically challenges over 2500 years of 'excluded middle' bivalent logic and rationality, making the case that nature and mind are multivalent. In fact, it is from the very notion of the identity *A* that the entirety of DSRP theory originates. Because without all of DSRP, *A* cannot exist. Thus, because some thing—any thing—exists, then DSRP exists.

1.3. Research Questions

Cabrera [73] expanded on distinctions theoretically by proposing in DSRP theory that: (1) distinctions are universal to mind and nature; (2) all distinctions (D) constitute an *existential/existential-negation* relationship between identity (*i*) and reaction (*o*) variables (what Cabrera calls *elements*); and (3) that distinctions are not reserved merely bounding the system but every identity within it and external to it. That is: any node in any network; or any element in an ecology; or any person, place, thing, or idea; in order to exist maintains a boundary between itself and what it is not both in nature (material systems) and in the human mind. DSRP theory predicts that increased awareness (metacognition of *D*-rule)

increases cognitive fluidity, complexity and robustness. Table 2 shows the structure of the identity–other distinctions rule. Table 3 shows the dependencies of the D-rule on the S, R, and P Rules respectively. Table 4 [83] shows the research matrix upon which our hypotheses, null hypotheses, and research design and findings are based.

Table 2. Identity–other distinctions rule or D-rule.

$D \equiv i \Leftrightarrow o$	A *Distinction* is defined as *identity* co-implying *other*		
An *identity* exists	An *other* exists	*Identity* co-implies *other*	A *distinction* exists
i	o	$i \Leftrightarrow o$	$\equiv D$

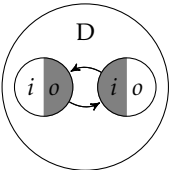**Table 3.** DSRP is necessary and sufficient adapted from [75].

Any identity–other **Distinction** is also:

- Two distinctions [possible]: $\{i, \neg i\}$ and $\{o, \neg o\}$
- A relationship (R_r^a): $i \xleftrightarrow[\text{exists}]{\text{negation}} o$
- A system with parts: i, o, and their relationship (R_r^a)
- Two perspectives [possible]: i and o

Table 4. Research questions for D-rule on four dimensions from [75].

	Existential *(Basic Research)*	**Efficacy** *(Applied Research)*
Mind *(cognitive complexity)*	**Does DSRP exist in the mind?** (i.e., does DSRP exist as universal, material, observable cognitive phenomena?)	**Is metacognitive awareness of DSRP effective?** (i.e., Does it increase ability to align cognitive complexity to real-world complexity? (a.k.a., parallelism)
Nature *(ontological complexity)*	**Does DSRP exist in nature?** (i.e., does DSRP exist as universal, material, observable phenomena?)	
	EMPIRICAL BASIS	

Thus, the set of D-rule studies described herein is part of a wider research program to empirically test the three major research questions shown in the matrix: basic research to establish the *existence* of DSRP in mind/nature and applied research to establish the *efficacy* of DSRP in understanding mind/nature.[1] The following research questions are addressed in our work on all four universal patterns:

1. *Existential* (basic research): focused on the questions: "Does DSRP exist? Does DSRP exist as universal, material, observable phenomena?"
2. *Efficacy* (applied research): focused on the questions: "Is DSRP effective? Does metacognition of DSRP increase effectiveness in navigating cognitive complexity in order to understand system (ontological) complexity?" This gets at the critically important issue of '*parallelism*'—defined as the probability that our cognitive organizational rules align with nature's organizational rules—which is central to the idea of the systems thinking/DSRP loop [75][2] (Figure 7).
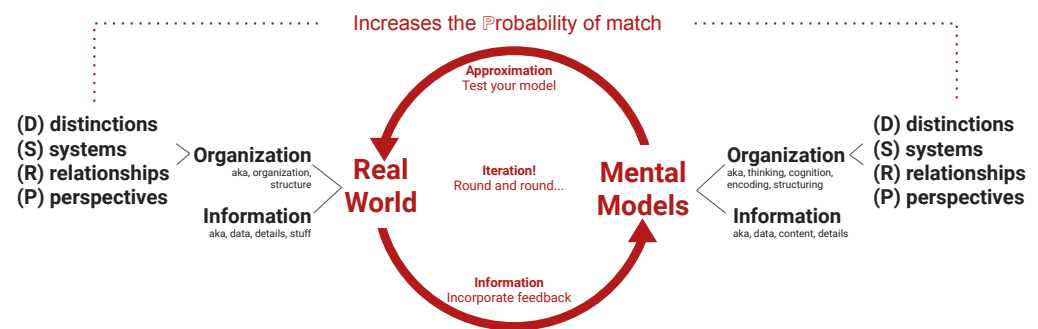
Figure 7. The ST/DSRP loop [75].

　　The seven studies presented herein are part of an "ecology of empirical studies" that include multiple meta-analytical literature reviews [73,87] and 26 new empirical studies. The reader is directed to the other three collections focused on: action–reaction relationship (R) studies [85], part–whole systems (S) studies [86], and point-view perspective (P) studies [84]. The reader may want focus on this ecology of the seven studies (herein) by reading them as an integrated ecology of studies. Alternatively, the reader may want to digest each study one at a time by reading, for example, the Methods (Section 2.1), Results (Section 3.1), and Findings (Section 4.1) for a single study. Thus, the empirical studies in this paper address more specific questions about the D-rule:

1. Does the D-rule *exist* in mind and nature (in the same way evolution or heliocentrism *exist*)?
2. Does awareness (metacognition) of the D-rule *increase effectiveness* in systems thinking or cognitive complexity, fluidity, etc.?

　　Although the designs of these research studies have focused on these questions separately, there is some overlap among these studies in their results. As a general guideline, however, it is safe to conclude that the *orange polyhedra*, *Rorschach*, *dog–tree–burger*, and *what is a shape?* studies have focused on *existential* questions, while the *D-mapping study*, *D-STMI study*[3], and *D-fishtank study* focused on *efficacy*. These studies aim to empirically quantify the theoretical predictions made by the DSRP theory, and the various implications, by showing that they are observable and significant.

　　The structure of the paper that follows goes through the methods, results, and discussion of seven empirical studies, such that each numbered subsection corresponds. Thus, for the first study, the methods are labelled 2.1, the results 3.1, and the discussion 4.1. In this way, the reader can take each study separately, or read the major sections in order.

2. Materials and Methods

　　Unless otherwise stated, the following is true for all studies. Subjects were given a task and asked to respond. Software was used to create an experiment for subjects to complete the task and/or answer the question. Prior to deployment, several pilot tests were conducted to ensure construct validity and to correct language-based confusion. Sample sizes were chosen for generalizability (e.g., given confidence level (CL = 95%), confidence interval (CI = 5), and a US population estimated at 350,000,000, the generalizable sample size was 384. Thus, we chose sample sizes larger than this number). The sample (N varies for each study; range of $N = 407$ to 34,398) was generalizable to the US population. Samples were chosen based on a normal distribution of tracts of the US population. Unless otherwise noted, samples were identified using the following demographics: US population; 50/50 gender split; between the ages of 22 and 65 years old; and splits that were representative of the census numbers for education (e.g., completion of high school, community college, college, masters, PhD); and provided by Alchemer. Data were then collected and analyzed; note that incomplete data and/or nonsense data were removed.

　　Detail of methods pertinent to each study are provided below for each study.

2.1. The Orange Polyhedra Study Methods

Statistical analysis was performed using R v 3.6.3. Counts and percentages were used to summarize the responses. McNemar's test was used for pairwise comparisons to assess whether the distribution of responses was significantly different between questions. Generalized linear mixed modeling was used to assess whether observed trend in probability is significantly associated with the level of distinction-making. Hypothesis testing was performed at 5% level of significance.

2.2. The Rorschach Study Methods

Statistical analysis was performed using R v 3.6.3. Hypothesis testing was performed at 95% level of significance. Counts and percentages were used to summarize the study variables. For hypotheses 1 and 2, analysis was performed using the chi-square G test (assuming a probability of 100% for each choice). For hypotheses 3 and 4, analysis was performed using chi-square test of independence.

2.3. The Dog–Tree–Burger Study Methods

Statistical analysis was performed using R v 3.6.3. Counts and percentages were used to summarize study variables. McNemar's test was used for pairwise comparisons to test hypothesis 2. The chi-square G test was used to test research hypotheses 1 and 3.

2.4. The What Is a Shape? Study Methods

Statistical analysis was performed using R v 3.6.3. Counts and percentages were used to summarize study variables. For hypotheses 1 and 3, analyses were performed using chi-square G, assuming a null proportion of >99% for the object. For hypothesis 2, the analysis was performed using McNemar's test.

2.5. The D-Mapping Study Methods

This study utilized data from the *Plectica systems mapping software* developed by Cabrera [97]. The sample (N = 34,398) consisted of a self-selecting sample of software users. Data were collected from a self-service web application that administers the Plectica software. Limited demographic data were collected. The data included all four patterns of DSRP, but the results provided herein are for the perspective pattern only. See [98] for a report of the wider data.

2.6. The D-STMI Study Methods

This study utilized data from the *systems thinking and metacognition indicator (STMI)* developed by Cabrera and Cabrera [82]. The sample (N = 1059) was a self-selecting sample of professionals between the ages of 18–65 who participated in the beta version of STMI post-validation. Data were collected from a self-service web application that administered the STMI. Limited demographic data were collected. The data cut across all four patterns of DSRP and "mixed and matched DSRP patterns" on both competence and confidence measures. The results provided herein are for the perspective pattern only. See [82] for a report of the wider data.

2.7. The D-Fishtank Study Methods

The sample (N = 1750 baseline; N = 350 Post) was generalizable to the US population (see above in general methods). The data cut across all four patterns of DSRP. The results provided herein are for the perspective pattern only. See [99] for a report of the wider data.

3. Results

3.1. The Orange Polyhedra Study

In the first set of tasks, subjects were asked to perform four tasks using the same image of an orange polyhedra ⬡ on a white background. There were two task sets, A—object and B—whitespace, and two conditions, 1—identity and 2—other. A1 asked subjects to click

on the 'object' and name it. A2 asked subjects to click on the 'ɴᴏᴛ-object' and name it. B1 asked subjects to click on the 'whitespace' and name it. B2 asked subjects to click on the 'ɴᴏᴛ-whitespace' and name it. Table 5 shows the underlying theoretical structure of the clicking and naming tasks.
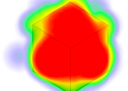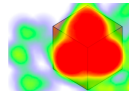
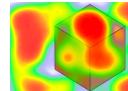**Table 5.** Structure of clicking and naming tasks.
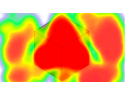
Set	A1	B1	A2	B2
1: Identity *[named]*	Click/name object			
			Click/name whitespace	
2: Other *[negated]*		Click/name Nᴏᴛ-object		
				Click/name Nᴏᴛ-whitespace

Table 6 shows the hypotheses for this study where: probability (*p*); identity (*i*); other (*o*); tangibility (*T*); naming (*N*); negation (ℕ).

Table 6. Hypotheses for the orange polyhedra study.

Null Hypotheses	Alternative Hypotheses
$H_{01} : pi = po = 0$	$H_{A1} : pi \neq po => 0$
$H_{02} : pT = pN = p\mathbb{N} = 0$	$H_{A2} : pT \neq pN \neq p\mathbb{N} => 0$

Task A1, OBJECT: Subjects (*N* = 374) were shown an orange polyhedra and were asked, "Click on the OBJECT and name what you clicked on". 100% or 374 of 374 clicked on the orange polyhedra (M = 1.00, SD = 0.00, *N* = 374, CI = 99%). Subjects named the orange polyhedra as follows:

- 82% of the subjects (307/374) named the polyhedra as either a 'cube', 'box', or 'square';
- 8.28% of the subjects (31/374) named the polyhedra as another polyhedra other than a cube. For example, a 'quadrilateral', 'diamond', or 'trapezoid';
- 6.68% of the subjects (25/374) named the polyhedra as the part they clicked on. For example, 'face', 'edge', or 'corner';
- 2.94% of the subjects (11/374) provided 'other' names that could not be interpreted, such as 'Jim' (perhaps literally giving the object a name) or 'roof' and 'heat lamp' (perhaps naming the object as something it looked similar to).

We can conclude from this that 100% of subjects visually identified the object and (visually) correctly distinguished (clicked) the object from its background and that 97.06% of subjects (linguistically) correctly distinguished (named) the object as a 'polyhedra' or parts of 'polyhedra'.

Task A2, Nᴏᴛ-OBJECT: subjects (*N* = 374) were then shown the same orange polyhedra again and asked, "Click on the Nᴏᴛ-OBJECT and name what you clicked on":

- 52.13% or 195 of 374 correctly clicked somewhere other than the orange object (a.k.a., the Nᴏᴛ-object) as instructed;
- 52.60% of the subjects (197/374) named the 'not-object' (i.e., the background) as instructed.
  - Of those: 49.74% (98/197) named it 'background', 'space', 'screen', or other like-terms; 25.38% (50/197) named it 'not-object'; and

- 21.82% (43/197) named it 'nothing', 'none', or 'blank', and 3.04% (6/197) gave 'other' names that could not be interpreted, such as 'desk' or 'unknown'.

- A total of 47.86% or 179 of 374 subjects incorrectly clicked on the object instead of the background space in the image and named it as follows:
- 43.85% of the subjects (164/374) named the 'object' (i.e., the orange polyhedra);
  - Of those: 85.36% (140/164) named the object 'cube', 'square', 'box', or like-terms; and
  - 14.63% (24/164) gave 'other' names that could not be interpreted, such as 'hex' or 'corona'.

Table 7 shows that 52.13% correctly clicked on the background of the object (or NOT-object) as instructed. Of the 52.13% subjects who clicked in the correct area (not-object), 96.95% named it something that indicates that they understood the concept of 'not-object' or the other condition as a negated object. A total of 47.86% incorrectly clicked on the object. It is unclear if those subjects that clicked on the object simply misunderstood the task, or failed to understand the instructions or the term 'NOT-object'.

Table 7. Click and name not-object task (percent correct).

Item	Number	Percentage
Clicked on NOT-object	195	52.13%
Clicked on object	179	47.86%
Named the not-object	197	52.60%
Named the object	164	43.85%
Stats: M = 0.52, SD = 0.50, *N* = 374, CI = 98%		

Task B1, WHITESPACE: in a third task, subjects (*N* = 374) were then shown the same orange polyhedra and asked, "Click on the WHITESPACE and name what you clicked on".

- A total of 83.42% (312/374) clicked on the whitespace as instructed and named it as follows:
  - 82.46% (254/308) named it 'whitespace', 'background', 'space', or other like-terms;
  - 10.38% (32/308) named it 'nothing', or 'blank'; and
  - 7.14% (22/308) gave 'other' names that could not be interpreted such as 'Susan' or 'ghost'.
- A total of 16.57% or 62 of 374 subjects incorrectly clicked on the object and named it as follows:.
  - 17.64% of the subjects (66/374) named the 'object' (i.e., the orange polyhedra).
    - Of those: 57.57% (38/66) named the object 'cube', 'square', 'box', or like-terms; 25.75% (17/66) gave 'other' names that could not be interpreted, such as 'excellent' or 'objection';
    - 2.94% of all subjects (11/374) did not provide names for their clicks.

Table 8 shows that when the instruction changed from a relatively unfamiliar term, 'not-object' to the more familiar term 'whitespace', correct clicks increased from 52.13% to 83.42%, and even though the task followed the previous task, 0% named the whitespace as 'not-object'.These results buttress the likelihood that some portion of subjects misread the prompt (as not-object is easier to read as object than whitespace) as the number of incorrect (on object) clicks fell from 47.86% to 16.57%. In addition, this illustrates that significantly more subjects are clear about the *identity* of an object than they are about the *other* of an object. In other words, when subjects are asked to click and/or name a positive object (whether the object is a polyhedra or blank whitespace), they are more successful than when they are asked to identify and name the negative object (NOT-object or NOT-whitespace). This is an area for future research.

Table 8. Click and name whitespace task (percent correct).

Item	Number	Percentage
Clicked on whitespace	312	83.42%
Clicked on object	62	16.57%
Named the whitespace	308	82.35%
Named the object	66	17.64%
Stats: M = 0.83, SD = 0.37, N = 374, CI = 99%		

Task B2, Not-WHITESPACE: In a fourth task, subjects (*N* = 374) were then shown the same orange polyhedra and asked to, "Click on the Not-WHITESPACE and name what you clicked on" (Results in Table 9).
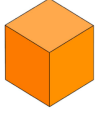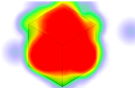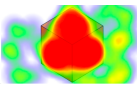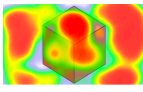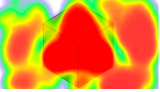
- A total of 89.57% or 335 of 374 clicked on the Not-whitespace (a.k.a., the object);
- 87.96% of the subjects (329/374) named the 'non-whitespace' (i.e., the orange polyhedra as instructed) as follows:
  - 77.50% (255/329) named it 'square', 'cube', 'box', or other like-terms;
  - 11.55% (38/329) named it 'non-whitespace'; and
  - 10.94% (36/329) gave 'other' names that could not be interpreted, such as 'bubba' or 'pole'.
- A total of 10.43% or 39 of 374 subjects incorrectly clicked on the ´whitespace´;
- 8.55% of the subjects (32/374) named the 'whitespace' (i.e., the background).
  - Of those who named it: 46.87% (15/32) named the object 'background', 'space', or like-terms;
  - 31.25% (10/32) named the object 'nothing', or 'blank'; and
  - 21.87% (7/32) gave 'other' names that could not be interpreted such as 'grinch' or 'ski'.
- A total of 3.47% (13/374) did not provide a name for their click.
  - This suggests that those who incorrectly clicked did so in error as they completed the task by naming what they clicked on correctly.

Table 9. Click and name non-whitespace task (percent correct).

Item	Number	Percentage
Clicked on Not-whitespace (object)	335	89.57%
Clicked on whitespace	39	10.43%
Named non-whitespace (object)	329	87.96%
Named whitespace	32	8.55%
Stats: M = 0.90, SD = 0.31, N = 374, CI = 99%		

Table 10 and Figure 8 illustrate the declining ability to make accurate distinctions based on tangibility, naming, and negation. Subjects were more likely to click and name correctly the more tangible the choice was. Conversely, the more intangible, negated, or unnamed the choice was, the higher likelihood of incorrect distinction making. The combination of negated, unnamed, and intangible characteristics produced (significantly) worse results.

Table 10. Clicks and naming differences.

Task/Action	**Click/Name Object (O)**	**Click/Name Noт-Whitespace (NW)**	**Click/Name Whitespace (W)**	**Click/Name Noт-Object (NO)**
Clicked correct	100% O	89.57% NW	83.42% W	52.13% NO
Clicked incorrect	0% NO	10.43% W	16.57% O	47.86% O
Named correct	97% O	87.96% NW	82.35% W	52.60% NO
Named incorrect	3% NO	8.55% W	17.64% O	43.85% O
Stats	M = 1.00 SD = 0.00 N = 374 CI = 99%	M = 0.90 SD = 0.31 N = 374 CI = 99%	M = 0.83 SD = 0.37 N = 374 CI = 99%	M = 0.52 SD = 0.50 N = 374 CI = 98%

Generalized linear mixed modeling was used to assess whether observed trend in probability is significantly associated with the level of distinction-making in Figure 9. The linear trend observed was not statistically significant ($p = 0.169$). Table 11 provides the descriptive statistics for the study.
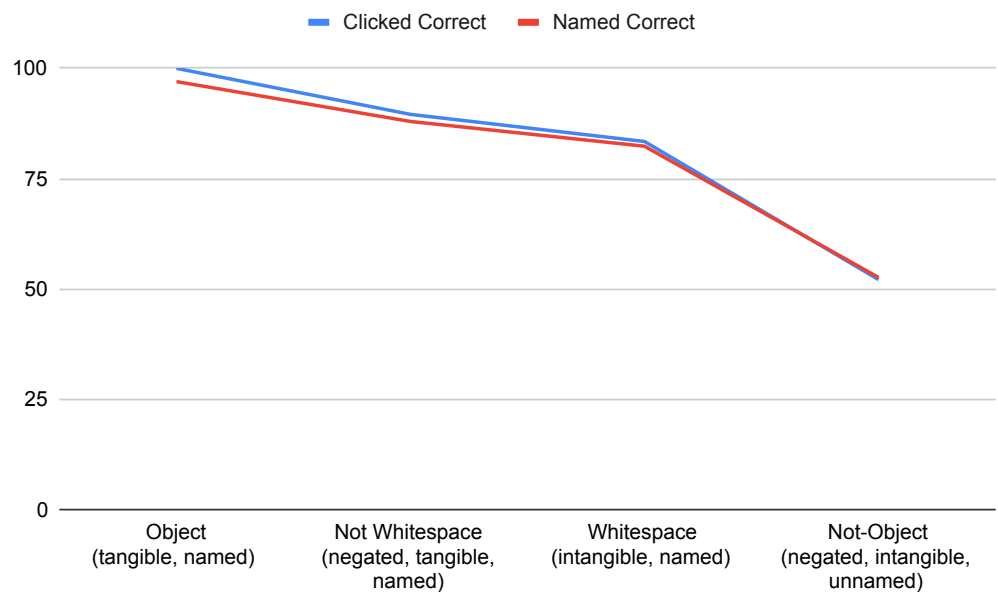
Figure 8. Distinctions difficulty tangible, named, negated.
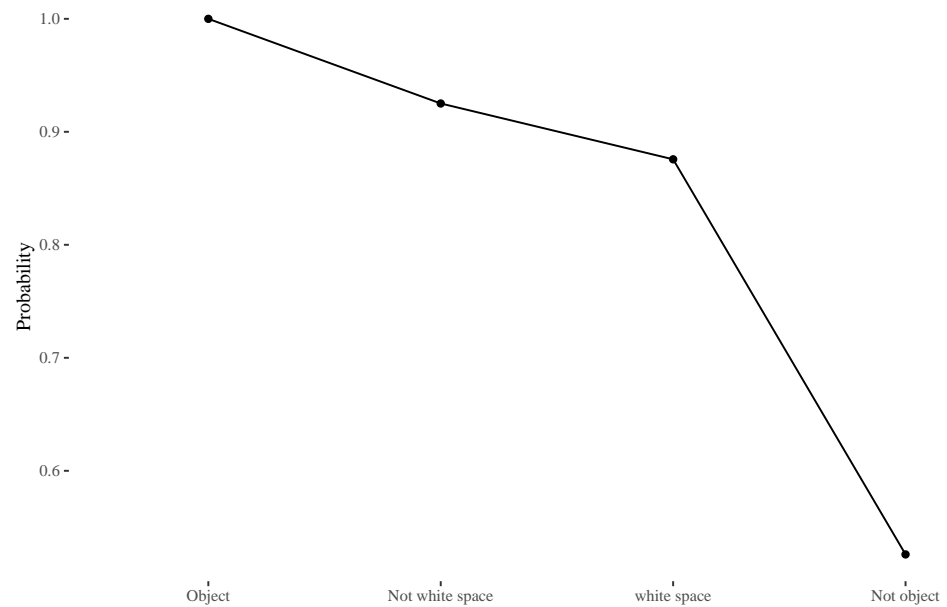
Figure 9. Probability of choosing the correct answer based on distinction-making.

Table 11. Descriptive statistics for the study sample.

	Incorrect	**Correct**	*p*
object		*N* = 374	
Diamond/rhombus		8 (2.14%)	
Other		34 (9.09%)	
Parts of a cube		25 (6.68%)	
Square/cube/box		307 (82.1%)	
Not-object	*N* = 179	*N* = 195	**<0.001**
Description of background	1 (0.56%)	95 (48.7%)	
Description of object	140 (78.2%)	0 (0.00%)	
No answer	6 (3.35%)	9 (4.62%)	
Not-object	1 (0.56%)	49 (25.1%)	
Nothing/blank	7 (3.91%)	36 (18.5%)	
Other	24 (13.4%)	6 (3.08%)	
White space	*N* = 62	*N* = 312	**<0.001**
Description of background	0 (0.00%)	254 (81.4%)	
Description of object	38 (61.3%)	0 (0.00%)	
No Answer	5 (8.06%)	6 (1.92%)	
Nothing/blank	2 (3.23%)	30 (9.62%)	
Other	17 (27.4%)	22 (7.05%)	
Non-whitespace	*N* = 40	*N* = 334	
Description of background	14 (35.0%)	1 (0.30%)	
Description of object	2 (5.00%)	253 (75.7%)	
No answer	1 (2.50%)	12 (3.59%)	
Non-whitespace	7 (17.5%)	31 (9.28%)	
Nothing/blank	8 (20.0%)	2 (0.60%)	
Other	8 (20.0%)	35 (10.5%)	

The results showed that 100% of respondents correctly chose the object compared to only 52.1% who chose the non-object. The percentages (%) of respondents who correctly identified white and non-whitespaces were 83.4% and 89.3%, respectively. Statistical analysis was performed using McNemar. *p* values were adjusted for false discovery rate.

Results (Table 12) showed that the percentages of correct answers were significantly higher when the subjects were asked to define objects compared to all other cases ($p < 0.001$ *** for all but one pairwise comparison). The percentages were also higher when respondents were asked to choose whitespace or non-whitespace than not-objects. The percentages of correct answers were significantly higher when respondents were asked to choose non-whitespace than whitespace ($p < 0.001$).

Table 12. Results for pairwise comparisons.

Null Hypothesis	Adjusted *p*
object ↔ not-object = 0	**<0.001**
object ↔ whitespace = 0	**<0.001**
object ↔ non-whitespace = 0	**<0.001**
not-object ↔ whitespace = 0	**<0.001**
not-object ↔ non-whitespace = 0	**<0.001**
whitespace ↔ non-whitespace = 0	**0.03**

3.2. The Inkblot Study

Subjects ($N = 374$) were shown a traditional Rorschach inkblot shown in Figure 10 and then asked, "Describe what you see".

Figure 10. Rorschach inkblot: *Describe what you see....*

The inkblot study had four null and alternative hypotheses. The first null hypothesis (H_{0_1}) was that, upon being *shown* the same thing, all subjects would distinguish it *conceptually* the same way, whereas the alternative hypothesis was (H_{A_1}) that subjects would distinguish it *conceptually* differently. The second null hypothesis (H_{0_2}) was that subjects would distinguish it in *name*, in the same way, whereas the alternative hypothesis (H_{A_2}) was that subjects would distinguish it in *name* differently. The third null hypothesis (H_{0_3}) was that there was equal probability of conceptually distinguishing all of the things that were conceptually distinguished, whereas (H_{A_3}) was that the probability was not equal. The fourth null hypothesis (H_{0_4}) was that there was an equal probability of distinguishing by *name* all of the things that were named, whereas (H_{A_4}) was that the probability was not equal.

Table 13 shows the hypotheses for the inkblot study, where: probability (*p*); concept (*C*); name (*N*).

Table 13. Hypotheses for the Rorschach study.

|	Null Hypotheses	Alternative Hypotheses
H_1	$pC_1 \lor pC_2 \lor pC_3 \lor pC_4 \lor \cdots \lor pC_x = 1$	$pC_1 \land pC_2 \land pC_3 \land pC_4 \land \cdots \land pC_x \neq 1$
H_2	$pN_1 \lor pN_2 \lor pN_3 \lor pN_4 \lor \cdots \lor pN_x = 1$	$pN_1 \land pN_2 \land pN_3 \land pN_4 \neq 1$
H_3	$pC_1 = pC_2 = pC_3 = \cdots = pC_x$	$pC_1 \neq pC_2 \neq pC_3 \neq \cdots \neq pC_x$
H_4	$pN_1 = pN_2 = pN_3 = \cdots = pN_x$	$pN_1 \neq pN_2 \neq pN_3 \neq \cdots \neq pN_x$

Although responses varied in what subjects saw—their unique responses (see Table 14 for the top eight)—fell into the four coded groups (see Figure 11): person, animal, thing, and other.

Table 14. Rorschach unique responses coded data.

Top 8 Unique Responses	Number	Percentage
Two of something (e.g., pairs, two, 2, etc.)	129	34.49%
Body Part	90	24.06%
Inkblot/Rorschach test	29	7.75%
Stingray	17	4.54%
Crab	16	4.27%
Elf/gnome/clown	14	3.74%
Bug/arachnid	9	2.40%
Turtle	8	2.13%

Other unique responses included: '3d x-ray image slice view', 'A crazy deer footprint in the mud', 'An angry chicken running at me', 'Road kill', and 'The white image looks like a ghost'. Figure 11 shows the categorized coded response types by count and percentage of the total (N = 374). A total of 34.49% of subjects saw two of something and 93% saw it as a person (31.28%), thing (40.37%), or animal (21.65%).
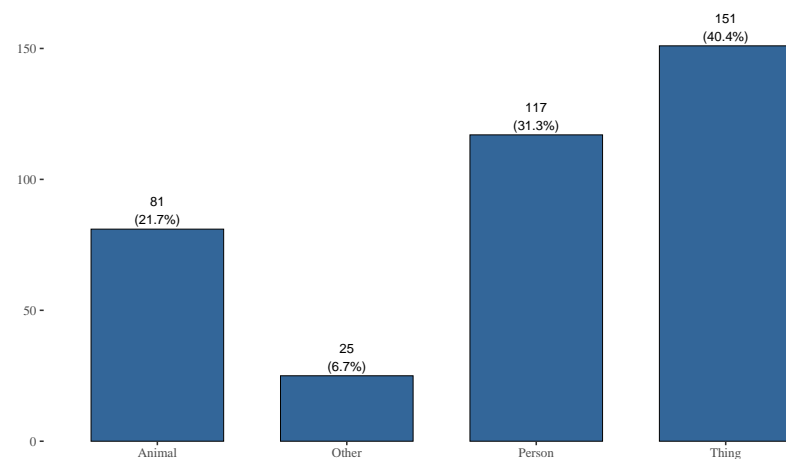
**Figure 11.** Observed concepts in the study.

Results showed that 40.4% of the respondents chose "things" followed by "person", and "animal". Only 6.7% chose "other." The probability (Table 15) of observing any of these objects with a probability ≠ 100% was less than 0.1% ($p < 0.001$ *** using the chi-square G test) supporting H_{A_1}.

Table 15. Pairwise comparisons.

Pairwise Comparison	p
Animal − Other = 0	**<0.001**
Animal − Person = 0	**<0.001**
Animal − Thing = 0	**<0.001**
Other − Person = 0	**<0.001**
Other − Thing = 0	**<0.001**
Person − Thing = 0	**<0.001**

A statistical analysis was performed using McNemar's test. Results showed that the probability of choosing "thing" was significantly higher than all other concepts ($p < 0.001$ ***) indicating a higher probability of choosing "thing". The probability of choosing "person" was significantly higher ($p < 0.001$ ***) than the probability of choosing "animal" and "other". Finally, the probability of choosing "animal" was higher ($p < 0.001$ ***) than the probability of choosing "other". These results support H3 and show that the probability of choosing concepts was not equal.

The probability of choosing any of the names (Figure 12) was not equal to 100% ($p < 0.001$ *** for all comparisons). Thus, the null hypothesis could be rejected (H_{0_2}) in favour of the alternative hypothesis (H_{A_2}).
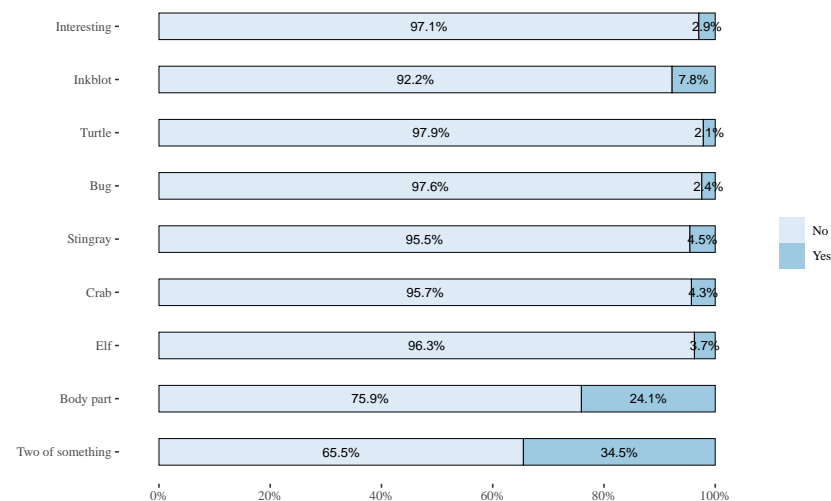
Figure 12. Frequency of the names identified by respondents ($N = 374$).

Post hoc pairwise comparisons (Table 16) showed that the probability of choosing "two of something" was significantly higher than any of the remaining coded choices ($p < 0.05$ for all pairwise comparisons). Similarly, the probability of choosing "body part" was significantly higher than the probability of choosing any of the remaining answers. Thus, the null hypothesis for H4 can be rejected. Analysis was performed using McNemar's test. p-values were adjusted for false discovery rate. Numbers represent the p-values for the corresponding McNemar's test.

Table 16. Post hoc pairwise comparisons.

	Bug	Crab	Elf	Inkblot	Interesting	Stingray	Turtle	Two of Something
Body part	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0038
Bug		0.2303	0.3772	**0.0036**	0.71	0.1742	0.8294	**<0.0001**
Crab			0.7513	0.0876	0.4094	0.8587	0.1621	**<0.0001**
Elf				**0.0398**	0.6302	0.6554	0.2768	**<0.0001**
Inkblot					**0.0097**	0.1204	**0.0022**	**<0.0001**
Interesting						0.3352	0.5851	**<0.0001**
Stingray							0.1204	**<0.0001**
Turtle								**<0.0001**

3.3. The Dog–Tree–Burger Study

Subjects (N = 374) were shown three familiar images (a dog, a tree, and a hamburger, as seen in Table 17), and given six word-based answer choices for each. They were then asked to "Check all the boxes that define each of the items." The hypotheses for this study are shown in Table 18 where: pi is the probability of choosing the positive *identity* (i.e., DOG, TREE, BURGER) and po is the probability of choosing the negated *other* (i.e., NOT-DOG, NOT-TREE, NOT-BURGER); po_1 is the probability of choosing *other* 1; po_2 is the probability of choosing the other 2; po_3 is the probability of choosing the other 3; and, $pi \ni \left\{ i \wedge \left\{ o_1 \vee o_2 \right\} \right\}$ is the probability of choosing the identity and both others.

Table 17 shows that subjects had little trouble identifying both the positive identity (e.g., dog is a dog) and the negated other (e.g., dog is also not a tree) conditions of a particular common object.

Table 17. Number and percentage of correct answers.

% Correct *	**Dog**	**Tree**	**Burger**
Dog	**361 (96.52%)**		
Tree		**358 (95.72%)**	
Burger			**358 (95.72%)**
Not a dog		*339 (90.64%)*	*295 (78.88%)*
Not a tree	*327 (87.43%)*		*310 (82.89%)*
Not a burger	*327 (87.43%)*	*316 (84.49%)*	

* bold indicates percent correct for positive identity (e.g., dog is a dog) and the italics shows percent correct for the negated other (e.g., dog is also not a tree) conditions.

Table 18. Hypotheses for dog–tree–burger.

	H_0	H_a
H_1	$pi = 1$	$pi \neq 1$
H_2	$po_1 = po_2 \wedge po_1 = po_3 \wedge po_2 = po_3$	$po_1 \neq po_2 \vee po_1 \neq po_3 \vee po_2 \neq po_3$
H_3	$pi \ni \left\{ i \wedge \left\{ o_1 \vee o_2 \right\} \right\} = 0$	$pi \ni \left\{ i \wedge \left\{ o_1 \vee o_2 \right\} \right\} \neq 0$

A total of 28 respondents were excluded as they checked all of the boxes. Thus, the final sample included 346 respondents. Descriptive statistics for this study are shown in Table 19.

**Table 19.** Descriptive statistics for the dog–tree–burger study.

	[ALL] $N = 360$		
Dog		Not a dog	
Dog (y):	334 (96.5%)	N	337 (97.4%)
Dog (n):	316 (91.3%)	Y	323 (93.4%)
Dog (n):	319 (92.2%)	Y	279 (80.6%)
Tree		Not a tree	
Tree (n):	324 (93.6%)	Y	310 (89.6%)
Tree (y):	331 (95.7%)	N	332 (96.0%)
Tree (n):	336 (97.1%)	Y	294 (85.0%)
Burger		Not-burger	
Burger (n):	328 (94.8%)	Y	311 (89.9%)
Burger (n):	336 (97.1%)	Y	300 (86.7%)
Burger (y):	332 (96.0%)	N	335 (96.8%)

Data were summarized using counts and percentages. Results represent the percentages that chose correctly.

Results showed (Figure 13 and Table 20) that the percentages of correct answers were not equal to 100% in all three cases. Thus, the null hypothesis can be rejected in favour of the alternative hypothesis.

Table 20. Chi-square G test results.

Dog	X^2	p
$p_{\text{dog}} = 100\%$	21.291	**<0.001**
$p_{\text{tree}} = 100\%$	38.878	**<0.001**
$p_{\text{burger}} = 100\%$	32.432	**<0.001**
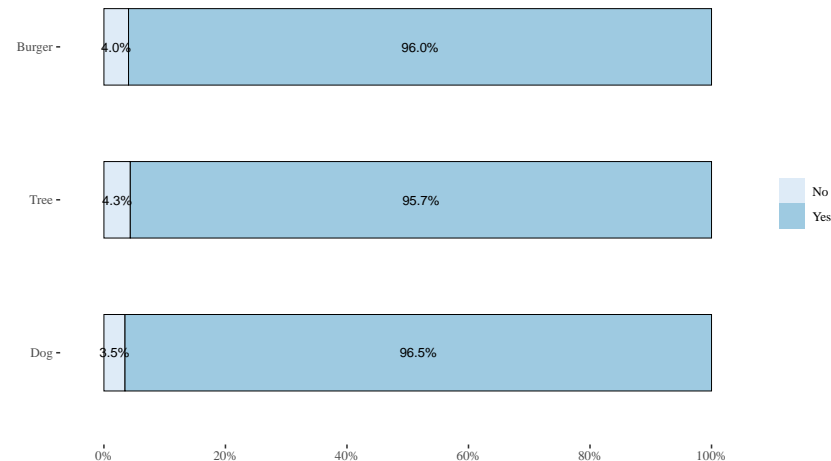
**Figure 13.** Responses for the included images.

Pairwise comparisons were performed using McNemar' test (Table 21).

Result showed (Figure 14) that the proportion of respondents who correctly chose the object was 75%. The proportion was significantly different from an expected value of 50% ($p < 0.001$ ***). However, it was significantly lower than an expected value of 100% ($p < 0.001$ ***).

Table 21. Results for pairwise comparisons.

Dog	
Dog (y) – not a dog (y) = 0	0.05
Dog (y) – not a dog (y) = 0	**<0.001**
Not a dog (y) – not a dog (y) = 0	**<0.001**
Tree	
Not a tree (y) – not a tree (y) = 0	0.07
Not a tree (y) – tree (y) = 0	**<0.001**
Not a tree (y) – tree (y) = 0	**<0.001**
Burger	
Burger (y) – not a burger (y) = 0	**<0.001**
Burger (y) – not a burger (y) = 0	**<0.001**
Not a burger (y) – not a burger (y) = 0	0.23
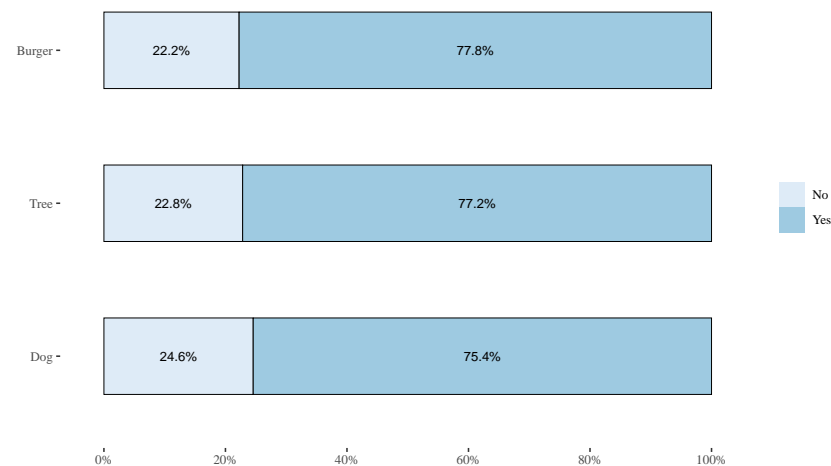
Figure 14. Proportion of respondents who correctly chose the "objected" and negated the remaining two objects.

3.4. The Shape/Not-Shape Study

In another set of tasks testing distinction making, subjects ($N = 374$) were asked to identify and name three familiar shapes as a baseline for subsequent tasks. The hypotheses for this study are shown in Table 22 where: p is probability; c is conceptual distinction; t is the terms used to make distinction; i is the *identity* (i.e., triangle, square, circle); o is the negated *other* (i.e., NOT-Triangle, NOT-Square, NOT-Circle); po_1 is the probability of choosing *other* 1; po_2 is the probability of choosing the other 2; po_3 is the probability of choosing the other 3; and, $p(o \ni \{o_1 \lor o_2\})$ is the probability that the other includes both others.

Table 22. Hypotheses for shape/not-shape study.

|	H_0	H_a
H_1	$pi_{c_1} \lor pi_{c_2} \lor \cdots \lor pi_{c_x} = 1$ $pi_{t_1} \lor pi_{t_2} \lor \cdots \lor pi_{t_x} = 1$	$pi_{c_1} \land pi_{c_2} \land \cdots \land pi_{c_x} \neq 1$ $pi_{t_1} \land pi_{t_2} \land \cdots \land pi_{t_x} \neq 1$
H_2	$p(o \ni \{o_1 \lor o_2\}) = 0$	$p(o \ni \{o_1 \lor o_2\}) \neq 0$

In the baseline, subjects overwhelmingly recognized these familiar shapes and named them accordingly (as square, triangle, and circle shown in Table 23). The responses for baseline objects were coded as yes or no based on the names provided.

Table 23. As a baseline, the majority similarly identify and name basic shapes (*N* = 374).

Shape	Identified/Named	*N* (%)
■ **"Square"** *(box, cube, etc.)*	No	16 (4.28%)
	Yes	358 (**95.7%**)
▼ **"Triangle"** *(pyramid, etc.)*	No	19 (5.08%)
	Yes	355 (**94.9%**)
● **"Circle"** *(round, sphere, etc.)*	No	25 (6.68%)
	Yes	349 (**93.3%**)

This set of three tasks establishes a baseline that an overwhelming majority of subjects can identify and appropriately name a square, triangle, and circle. When answers were coded for similarities and grouped, the results showed that, at the same time that subjects recognized the square, triangle, and circle as a baseline, they also included multiple similar attributes, such that several identity statements could be true. For example: [shape] is circle, [shape] is black, [shape] is black, [shape] is round. These data are shown in Table 23.

Results showed (Figure 15) that the percentage of respondents who correctly identified the object was >90% in all three situations (*p* < 0.001 ***) supporting H1.
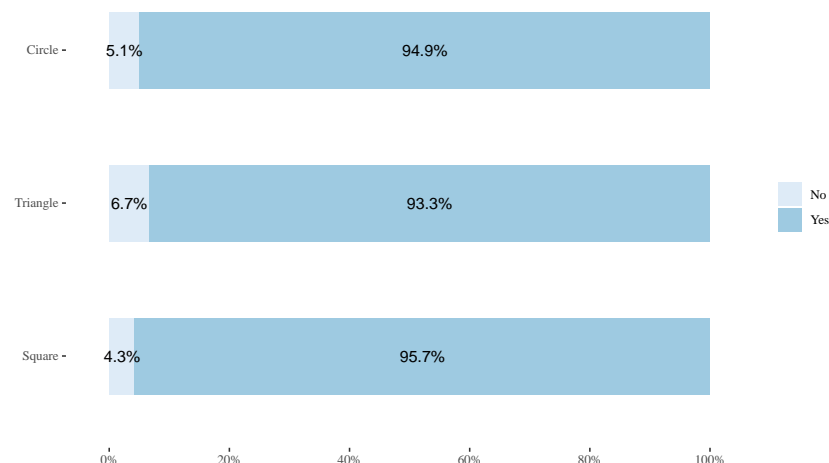
Figure 15. Responses to baseline objects.

The analysis was performed using chi-square G, assuming a null proportion of >99% for the object. The results (Table 24), although >90%, were significantly different from the expected probability of 100%.

Table 24. H1 test results for the shape/not-shape study.

Shape	*N* (%)	*p*
Square:	40.595	**<0.001**
Circle:	62.893	**<0.001**
Triangle	122.07	**<0.001**

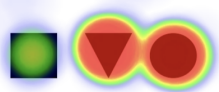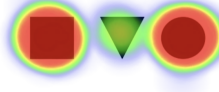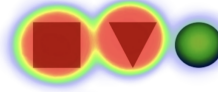Table 25 shows counts and percentages for unique names and coded groups for square, triangle, and circle. Note that in support of the alternative hypothesis, subjects showed both similarities and differences in their naming and concepts of the shapes. Overwhelmingly, subjects "concepted" the shapes similarly (and "correctly") while also differing on the finer-grain choices they made to describe each shape.

Table 25. Counts and percentages for various unique names and coded groups.

"Square" (box, cube, etc.)	343	91.71%
Description of image (black, dark, etc.)	18	4.81%
Other (hole, nick, etc.)	13	3.47%
"Triangle"	350	93.58%
Description of image (black, inverted, etc.)	7	4.54%
Other (rectangle, corner, etc.)	17	1.87%
"Circle" (round, sphere, etc.)	358	95.72%
Description of image (black)	2	0.53%
Other (yes, goal, etc.)	14	3.74%

Subjects ($N = 374$) were then asked to complete three tasks: (1) to "click on not-square", (1) to "click on not-triangle", and (1) to "click on not-circle". This specifically tests the ability of individuals to see the two elements of distinction making (identity and other). Subjects overwhelmingly clicked on the expected "not object" areas, as shown in the three heat map images in Table 26.

Table 26. Heatmaps for distinguishing shapes.

Clicked on Not-Square	Clicked on Not-Triangle	Clicked on Not-Circle
92.24%	93.58%	94.38%
M = 0.92	M = 0.94	M = 0.94
SD = 0.27	SD = 0.28	SD = 0.30
N = 374	N = 374	N = 374
CI = 99%	CI = 99%	CI = 99%

Analysis was performed using chi-square G (Table 27). The percentage of respondents who correctly responded to the positively and negatively worded questions for each object was significantly different from zero ($p < 0.001$ *** for all three objects). Thus, the null hypothesis can be rejected in favour of the alternative hypothesis.

Table 27. H2 test results for shape/not-shape study.

Pairwise Comparisons	N (%)	p
Correctly respond to "square" and "not-square"	334 (89.3%)	**<0.001**
Correctly respond "circle" and "not-circle"	330 (88.2%)	**<0.001**
Correctly respond to "triangle" and "not-triangle"	326 (87.2%)	**<0.001**

3.5. The D-Mapping Study Results

A study ($N = 34,398$) of aggregate data of software users in the Plectica systems mapping software[4] determined what people did (and did not do) when they mapped a system. A total of 48% did *nothing*, which is consistent with case study research where people faced with an open-ended problem or question (mapping prompt) and/or a blank page or screen (mapping area) had no response and took no action (i.e., they 'froze'). Table 28 shows additional results.

Table 28. Actions users took—and did not take—when systems mapping ($N = 34{,}398$).

Percentages	Action taken	Number
48% ($N = 16{,}516$)	distinguished nothing (i.e., did not think)	0 times
52% ($N = 17{,}882$)	distinguished things	2,066,654 times
of those 48%	broke down their distinctions into parts	769,120 times
of those 46%	related things	565,999 times
of those 25%	distinguished their relationships	87,318 times
of those 16%	took at least one perspective	39,398 times
of those 4%	distinguished their perspective taking	16,668 times

These data provide insight into what people do when mapping using systems thinking, and what they do not do (or could do, but do not). Table 29 differentiates between what people do (or did) and what they do not do (or could or should do). It provides a good baseline for what systems thinkers should continue to do and what they should do more of.

**Table 29.** What people do and do not do in systems mapping ($N = 34{,}398$).

What People Tend to Do	What People Tend Not to Do
Make identities (D^i)	Rarely consider the other (D_o)
	Rarely challenge or validate the identities (D_o^i) they make
Make part–whole systems (S_w^p)	Rarely challenge the way (or consider alternative ways) that parts are organized into wholes ($S(P)$)
	Rarely think +1 and −1 from the level they are thinking about ($w = p$ or $p = w$)
	Rarely relate the parts of the whole ($p \overset{R}{\Longleftrightarrow} p$)
Occasionally relate things (R)	Almost never distinguish their relationships (RD) or zoom into them and add parts (RDS)
	Sometimes look for the *direct* cause (R), but rarely think in webs of causality (S of Rs)
Take only their own perspective (P) (implicitly)	Almost never take explicit perspectives (P_v^ρ)
	Rarely take multiple perspectives ($n * P_v^\rho$)
	Rarely take conceptual perspectives (C_ρ)

Specifically, where identity–other distinctions are involved, (48% of people distinguished *nothing* whereas 52% of people distinguished 2,066,654 identities. At the same time, people rarely consider the other (D_o) or validate the identities (D_o^i) they make.

3.6. The D-STMI Study Results

In a study utilizing the systems thinking and metacognition indicator (STMI) [82] ($N = 1059$), subjects exhibited the well-known Dunning–Kruger Effect [100], where confidence was higher than competence in distinction making, as shown in Figure 16. This was the case across all four universals of the DSRP theory (part–whole systems, action–reaction relationships, and point-view perspectives) but herein we focus on the distinction making results. The subjects' aggregate distinction making competency/skill score was 68.5 whereas the confidence score was 86.5—a difference of 18.
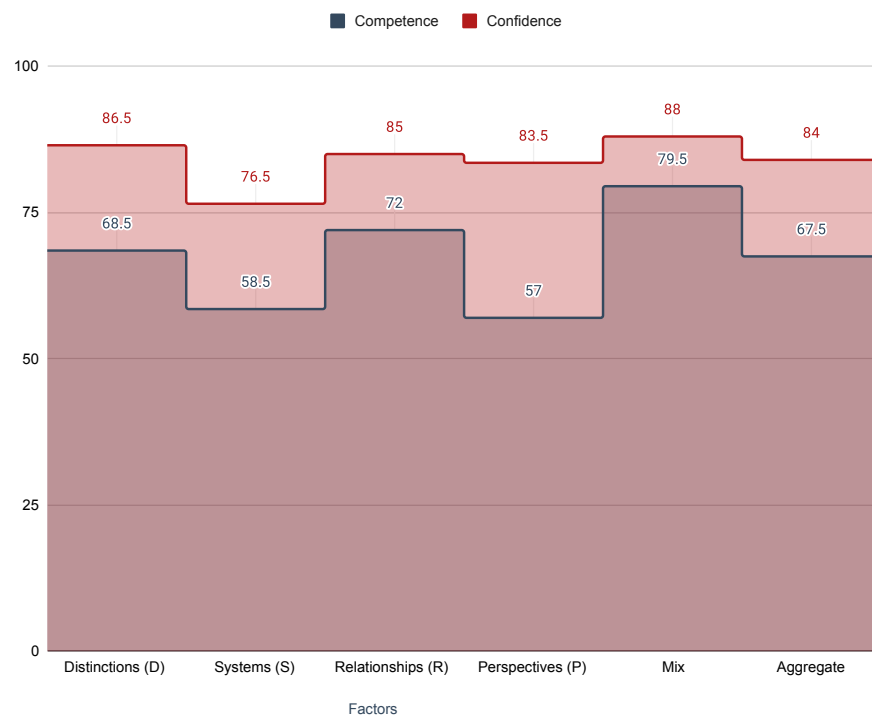
Figure 16. Dunning–Kruger effect in distinction making.

3.7. The D-Fishtank Study Results

In the fishtank study, subjects ($N = 1750$) were asked to describe what they saw in a fishtank scene (the static image in Figure 17).

Figure 17. Describe what you see. . . [83].

Responses established the baseline data. Then subjects ($N = 350$) were exposed to a less than one-minute treatment that consisted of reading the bullet text shown in Table 30, which is excerpted from [83].

Table 30. Less than 1 min of treatment excerpt from [83].

Things to consider from the identity–other distinction rule (D):

- Distinctions are all around us; it is how we name, identify, and differentiate things, ideas, or objects from one another.
- The identity–other structure of distinctions means that any object or idea is both an identity and an other (e.g., "us" vs. "them").
- The distinctions you make can be general and/or specific (e.g., "a cup" vs. "a red porcelain cup").
- Often a single distinction can become many more distinctions when one looks closer at its meaning (e.g., "birds" can be further distinguished to be owls, eagles, seagulls).

Subjects were then shown the same fishtank image and asked again to "Describe what they see". The quantitative data for the distinctions (D) fishtank study is fully explicated in Cabrera [83], so we will only summarize herein. Results showed that the "PostD responses have significantly more words overall and those words are more complex" [83]. Table 31 shows the differences. Importantly, according to research by Lewis and Frank (2016) [101], word length is a valid indicator of the complexity of ideas. The pre- and post-data show increases in the number of characters, words, and length to indicate corollary increases in cognitive complexity of responses between the pre- and post-conditions.

Table 31. PreD and postD aggregate response data excerpted from [83].

	PreD	**PostD**	**Difference**
Number of characters (including spaces)	17,691	24,308	+27.22%
Number of characters (without spaces)	10,291	14,752	+30.24%
Number of words (including repeated words)	2098	3071	+31.68%
Number of syllables (including repeated words)	3246	4558	+28.78%
Unique words	251	453	+44.59%
Number of characters (no spaces) for unique words	1418	2626	+46.00%
Number of syllables for unique words	492	901	+45.39%
Total unique word occurrence	1832	2680	+31.64%

Cabrera et al. [83] explain that: Results in Tables 32 and 33 show that the distribution of number of concepts (i.e., the number of individual entries the subject made, "raw data") was not significantly different before and after treatment ($p = 0.062$ using the Wilcoxon signed-rank test). Data ($N = 383$) were summarized using median (IQR). Statistical analysis was performed using Wilcoxon signed-rank test. However, the median number of words used after treatment (Mdn = 6, IQR 3–10) was significantly higher than the median number of words used before treatment (Mdn = 4, IQR 3–7, $p < 0.001$ ***). Similarly, the median number of characters used after treatment (M = 29, IQR 14–53) was significantly higher than the median number of characters used before treatment (Mdn = 12, IQR 13–36, $p < 0.001$ ***).
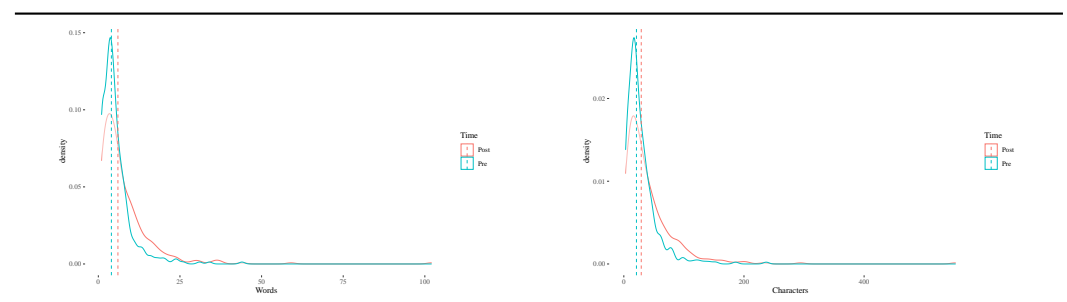
Table 32. Distribution of words and characters (vertical lines represent median) for distinctions (D) excerpted from [83].

Table 33. Comparison of raw counts, words, and characters before and after D-treatment excerpted from [83].

	Pre	Post	P.overall
No. concepts	3.00 [1.00; 4.00]	3.00 [1.00; 4.00]	0.062
No. words	4.00 [3.00; 7.00]	6.00 [3.00; 10.0]	**<0.001**
No. characters	21.0 [13.0; 36.0]	29.0 [14.0; 53.0]	**<0.001**

4. Discussion of Findings

These seven studies provide an "ecology" of findings about identity–other distinctions. Each study furthers our understanding of identity–other distinctions (a.k.a., boundaries) and answers important questions about: (1) how and why they form; (2) their internal and external dynamics; (3) the roles they play in individual and social cognition; (4) the roles they play in metacognition; and (5) the effects of metacognitive awareness of distinctions on cognitive complexity.

4.1. The Orange Polyhedra Study

The *orange polyhedra study* helps to better understand how people make distinctions, which include the positive identification of something (the 'identity') and the negation of some other thing(s) (the 'other'). The results of this study indicate that any identity—no matter how discrete (orange polyhedra) or indiscrete (empty whitespace) it is—is also perceived as an other or not-identity. It is also clear that even the most basic things (identities, such as a whitespace or cube) will go by different linguistic labels (words). Therefore, it appears that words alone are not an adequate representation of the concepts or things themselves. Any two people may use the same words to describe different things or use different words to describe the same thing. We see in Table 10 and Figure 8 that:

- People have an easier time identifying and naming objects than not-objects
- When the identity is an object, they do better;
- When the identity is a not-object, they do worse;
- When the other is an object, they do better; and
- When the other is a not-object, they do worse.

4.2. The Rorschach/Inkblot Study

The *Rorschach/inkblot study* suggests that the perceived identity of an object varies widely and that the recognition and naming of that perceived identity at the level of individual-cognition can take on four conditions at the aggregate level of social-cognition:

1. *Same/same* (i.e., the same identity can be called by the same name);
2. *Same/different* (i.e., the same identity can be called by different names);
3. *Different/same* (i.e., different identities can be called by the same name); or
4. *Different/different* (i.e., different identities can be called different names).

The results suggest that when shown an ambiguous object people will see (visually and in their minds) many *different* identities. These data indicate that something non-discrete and abstract, such as an inkblot, can yield dramatically different concepts, identification, and naming among individuals. In other words, people distinguish the same things both *differently* and *similarly*. The fact that 34.49% of subjects saw two of something and that nearly 93% saw it as a person (31.28%), thing (40.37%), or animal (21.65%), means that while people see things differently, they also see things the same. This is the paradox of distinction making: as individuals, we often distinguish things differently, but in the aggregate, those varied distinctions create a "statistical cloud" within which there is aggregate agreement.

4.3. The Dog–Tree–Burger Study

The *dog–tree–burger study* reveals that people distinguish and name objects both by their *positive-identity* and their *negative-other*. It also shows that the 'other' can be (and often is) a 'system of others'.[5] This means that not-dog is comprised of parts (i.e., not-tree,

not-burger, *ad infinitum*). It may be that these negated sets (or part–whole systems of things) form a cognitive "dark matter" that binds the contents of one's cognitive universe together, and not without important effects. For example, if TRUCK is not-CAR and FORD F-150 is a TRUCK, then without learning it or being told, one could conclude that a FORD F-150 is not-a-CAR. Although further research is needed, this may also be instrumental in "going up a level" where certain identities are part-of or NOT-part-of (systems), related-to or NOT-related-to (relationships), or seen-by or NOT-seen-by other identities (perspectives) and, therefore, stringing together a logical or sense-making cognitive universe (dominated by "not matter") that allows us to conclude things, such as '*while an apple is not an orange, both are fruits*'.

These data explicate that subjects not only identify (in this case common) objects by what they are (identity) but also by what they are not (other). Thus, 'not-a-tree' and 'not-a-burger' are other terms for 'dog', and vice versa. This establishes the co-identities of any given item: dog and not-tree. However, it also means that, for example, tree and burger are both not-dog, thus establishing a part–whole set of things that are not-dog, which explicates the idea that the 'other' is often a 'system of others'.

The data in Table 17 also show that *identity* and *other* are *interchangeable*: that a DOG or TREE or BURGER can alternatively be thought of, respectively, as NOT-DOG, NOT-TREE, and NOT-BURGER.

4.4. The Shape/Not-Shape Study

The *shape/not-shape study*: the results of this study, such as the Inkblot study, show that identity–other distinctions are both diverse at the individual-cognition level and also aggregate remarkably similarly at the level of social-cognition. For example, Table 23 shows that people basically have a shared mental model of the basic shapes: triangle, square, and circle. This study also reinforces the conclusions that: (1) people conceptually and visually distinguish identity and other; (2) the 'other' is more often than not a 'system of others'; and (3) explicates that distinction making is occurring individually (psychologically/cognitively) and in groups (sociologically/statistically), which has significant implications on shared meaning and knowledge creation.

However, there are two other important conclusions that can be taken from these results. First, people are able to conceptually and visually distinguish between identity and other without difficulty, indicating the universality of identity–other distinctions. Second, both *identities* and *others* (e.g., *not-identities*, or not-square, not-triangle, and not-circle), are part–whole sets (others rather than a single other). However, in this case, we see that these part–whole sets of 'otherness' (see Table 34) are mediated and formed socially and statistically rather than by an individual (although it is almost certainly occurring within the individual as well). Thus, several *existential* or *is* statements could make up the identity ([shape] is circle, [shape] is black, [shape] is black, [shape] is round; shown in Figure 18) and several *existential* or *is* statements could make up the other ([item] *is* not-gerbil, [item] *is* not-rabbit, [item] *is* not-tree as shown in Figure 5 and Tables 10 and 17, etc.)

This seemingly simple idea may lie at the core of shared meaning making, normative meaning, and knowledge generally. From the data in Table 26, we can see in Table 34 that the other is a statistical cloud—a part–whole structure.

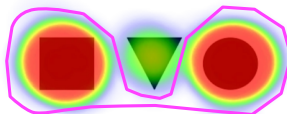**Table 34.** Creation of part–whole *other* in individual and social cognition.

Clicked on Not-Square	Clicked on Not-Triangle	Clicked on Not-Circle

Figure 18 illustrates (from the data in Table 25) that identity is also a part–whole structure at both the levels of individual and social cognition.
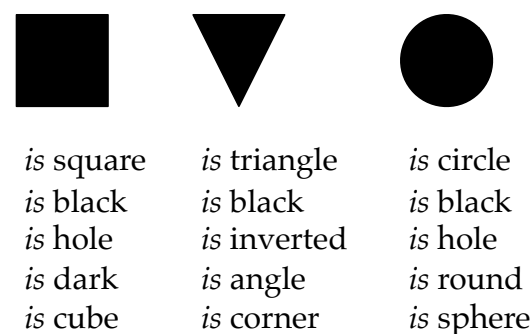

is square	*is* triangle	*is* circle
is black	*is* black	*is* black
is hole	*is* inverted	*is* hole
is dark	*is* angle	*is* round
is cube	*is* corner	*is* sphere

Figure 18. Creation of part–whole *identity* in individual and social cognition.

It is also curious, given the orange polyhedra study, how many people clicked on other objects (non-whitespace) when asked to click on something other than object x. This establishes a strong preference for "somethingness" over "nothingness", object-orientation over conceptual fluidity.

4.5. Dependency Research Studies

In other research studies, the part–whole variables of systems (S) [86], the action and reaction variables of relationships (R) [85], and the point and view variables of perspectives (P) [84], were all shown to be identity and other distinctions (D). For example, as part of research on part–whole systems (S), Cabrera found [86] that both the parts and the wholes were identity–other distinctions.

4.6. The D-Mapping Study

The prior studies get at the *existence* of identity–other distinctions. The **Fishtank**, **STMI**, and **D-mapping** data shows that identity–other distinctions not only exist but can be utilized as a metacognitive skill with highly statistically significant effects and can be measured in terms of competence and confidence.

Table 28 shows that nearly half of subjects (48%!) *'freeze up'* when faced with a blank canvas and the task of thinking through an issue, thought, problem, or system. This means they 'freeze up' in the act of making the very first identities (which also means they never get to others). This aligns with case-based and anecdotal experience that, when faced with the 'blankness' of open-ended questions or free reign, many people will simply be overwhelmed by options. For the 52% of people who did something in this study, the very initial act was to create an *identity*—indicative of a distinction. Table 28 goes on to detail the various things the sample of 34,398 people did and did not do. In terms of metacognition, much can be learned from these statistics. Table 29 summarizes these data and also what we can learn by providing a list of things we can continue to do and things we can attempt to do more of. This list is a *best practices* for systems thinking and metacognition. Becoming aware of (metacognition) and, therefore, doing more of the items on this list is, part and parcel of, systems thinking.

4.7. The D-STMI Study

Specifically, in both the *fishtank study* and the *STMI study*[6] we see that the theoretical universal of identity–other distinctions can also be utilized as metacognitive skills that can be measured in both competence/skill and confidence. The Dunning–Kruger effect is evident in our sample and illustrates that we should be careful not to overestimate our competency in the distinction making skill.

4.8. The D-Fishtank Study

The *fishtank study* shows that, with high statistical significance, a short (less than 1 min) intervention based on the basic concepts of identity–other distinctions can have a positive effect on the complexity of cognition. People not only see quantitatively more, but qualitatively deeper as well. Given the limited exposure to treatment (on average, a 28.11 s read of bullets of text), these findings indicate a statistically significant increase in the degree to which people made more detailed distinctions and more distinctions. With a more substantive treatment (such as a short course) one can imagine the effects may be transformative.

4.9. Summary of Findings on Existence, Universality, Efficacy, and Parallelism

The findings in this ecology of studies, focusing on *identity–other distinctions*, are detailed above. It is important to note that all of these findings confirm specific predictions made by the DSRP theory. In these seven studies, we see that the *identity* and *other* elements of the *distinctions* pattern are *inextricably linked*, *co-implying*, and *interchangeable*. This idea is explained in Cabrera et al. [75] where "Equation (2) shows that, if an identity (*i*) called *A* exists ($\exists$), it is co-implied ($\Leftrightarrow$) that an other (*o*), $\neg A$ exists and vice versa (red indicates universal DSRP elements and the blue represents the information variables). This means that if *A* exists (and *A* represents *anything*), then an identity–other distinction (D_o^i) *must also* exist".

$$\exists A_i \xoverset{implies}{\Longrightarrow} \exists \neg A_o$$

$$\exists \neg A_o \xoverset{implies}{\Longrightarrow} \exists A_i$$

Therefore:

$$\exists A_i \xoverset{co\text{-}implies}{\Longleftrightarrow} \exists \neg A_o$$

(2)

Thus, in Equation (3), we see that the *identity–other* elements of *distinctions* are *universal* to all forms of objects/things, concepts/ideas, or boundaries, etc. Moreover, these universal elements are *interchangeable*, such that any *identity* can also function as an *other* and vice versa:

$$D = i \xoverset{co\text{-}implies}{\Longleftrightarrow} o$$

$$f : i \to o$$

$$f : o \to i$$

(3)

In other research studies, the action and reaction variables of relationships (R) [85], the part and whole variables of systems (S) [86], and the point and view variables of perspectives (P) [84], were all shown to be identity–other distinctions (D), for example, the elements of S, R, and P are identity–other boundary distinctions. Similar to the studies presented herein for identity–other distinctions (D), an ecology of studies was undertaken to test the existence and efficacy of, respectively, S, R, and P rules. These studies show that, with high statistical validity, the identity–other distinction is a factor in the formation of a part–whole system, action–reaction relationships, and point-view perspectives. From the results of these seven studies, we can conclude that identity–other distinctions (D) are:

1. Universal to the organization of information:
   (a) in the *mind* (i.e., thinking, metacognition, encoding, knowledge formation, science, including both individual and social cognition, etc.; and
   (b) in *nature* (i.e., physical/material, observable systems, matter, scientific findings across the disciplines, etc.).
2. Made up of elements (identity, other) that are:

(a)   *Co-implying* (i.e., if one exists, the other exists; called the co-implication rule);

(b)   Related by a special[7] Relationship: *existential/existential-negation* (i.e., is/is-not); and

(c)   Act simultaneously as, and are, therefore, interchangeable with, the elements of relationships (action, reaction), systems (part, whole) and perspectives (point, view). This is called the simultaneity rule.

3.   Mutually-dependent on action–reaction relationships (R)), part–whole systems (S), point-view perspectives (P), such that D, S, R, and P are necessary and sufficient; and

4.   Taken metacognitively:

(a)   Constitute the basis for making *structural predictions* about information (based on co-implication and simultaneity rules) of observable phenomena and are, therefore, a source of creativity, discovery, innovation, invention, and knowledge discovery; and

(b)   *Effective* in navigating cognitive complexity to align with ontological systems complexity.

5. Conclusions

With these findings in mind, we can return to our table of research questions (Table 4) to summarize what was found. In conclusion, these data suggest the observable and empirical *existence*, *universality*, *efficacy*, and *parallelism* (between cognitive and ontological complexity) of identity–other distinctions (D), and with high statistical significance point to the conclusions in Table 35.

Table 35. Summary Table of Conclusions.

Conclusions	Summary
Globally and universally, identity–other distinctions exist.	D_o^i exists.
Contrary to prevailing belief, things are defined not solely by their essence or accepted definitions, but also in relation to the *other* things they are with.	D_o^i is relative.
Distinctions are made at the individual and collective level.	D_o^i is universal.
At the individual level, people make a diversity of distinctions, collectively, they see things similarly.	In a pool of difference, we distinguish similarly.
We use: different names for different things; different names for the same things; same names for different things; and same names for the same things.	Left implicit, D confuses, made explicit D clarifies.
Cognitively speaking, there is a parallel invisible universe of not-things, which provide the 'ether'	Negated identities matter.
Unstructured, people have a hard time getting their thinking started.	D-rule jump starts thinking.
Identity–other are both part–whole systems of 'is's' and 'is-not's'.	D is S-dependent.
We also know that the other is an identity.	*i* and *o* are interchangeable.
The D-rule is dependent on S, R, and P rules, and S, ,R and P rules are dependent on the D-rule.	DSRP is massively parallel and fractal.
The more tangible and explicit things are, the easier it is for people to make identity–other distinctions. People miss things when they are not tangible/explicit, which is a lot.	Awareness of the D-rule decreases bias.
We know what people do and do not do, which could help us improve thinking. Namely: rarely consider the other; people rarely challenge existing distinctions; rarely validate.	Awareness of D-rule improves thinking.
People have greater confidence than competence in distinction making.	We are overconfident with D_o^i
A relatively short treatment in the D-rule can dramatically affect cognitive ability and complexity.	The "D-rule" makes you smarter.

Institutional Review Board Statement: Ethical review and approval were waived for this study, due to no collection of personal or identifying data.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to privacy, human subjects, and ethical considerations.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

DSRP	DSRP theory (distinctions, systems, relationships, perspectives)
D	identity–other distinctions
S	part–whole systems
R	action–reaction relationships
P	point-view perspectives
STMI	systems thinking and metacognition inventory
IQR	interquartile range
GLMM	generalized linear mixed modeling
RDS	relate–distinguish–systematize jig

Notes

[1]　Some readers may find it confusing that we combine what might be called a *positivist* or *objective* and a *constructivist* or *phenomenological* or *subjective* epistemic views. We see no particular difficulty as the philosophical debate as to their incompatibility appears to be little more than a false dichotomy. It seems quite obvious to us that, given both everyday behavior and empirical evidence, not one of us humans or animals go about their day as if nothing is real. Likewise, even the most cantankerous positivist would concede that our mental models are real and influence real world behavior, even when the models themselves are not valid. Alas, we consider this to be the domain of philosophers (which we are not) and focus on following where the empirical science and data lead us, regardless of whether or not it violates one of our epistemic beliefs. We see absolutely no problem mixing positivism and phenomenology, for example. Nor do we see an issue mixing reductionism and holism or nature and nurture or behaviorism and cognitivism. These are false dichotomies that likely should be placed in the dustbin of history.

[2]　From [83], "It should be noted that the ST/DSRP loop is the mirror opposite of confirmation bias. Confirmation bias reverses this loop, by *fitting* reality to one's mental models, whereas DSRP-systems thinking *fits* mental models to real-world observables and feedback. *Parallelism* is therefore the degree to which one's cognitive paradigm, style, or mindset, aligns with nature's. One purpose of this research program, is to determine the degree to which DSRP theory accomplishes this parallelism".

[3]　STMI is the acronym for the systems thinking and metacognition inventory

[4]　full disclosure, Plectica systems mapping software was invented by Dr. Derek Cabrera and used for years as a pilot software for research purposes (it was originally called MetaMap). Cabrera later co-founded Plectica and developed the software further as a consumer application. Plectica was then sold to Frameable and Cabrera is no longer actively involved in the company.

[5]　The *why not a dot? study* indicates a similar part–whole structure for *identities*, meaning that both identities and others are part–whole structures [84].

[6]　the STMI study focused on more than just the effects of distinctions; see [82].

[7]　"special" here refers to the specific relationship. In contrast to general or universal relationships.

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