*Article*

# Relationships Organize Information in Mind and Nature: Empirical Findings of Action-Reaction Relationships (R) in Cognitive and Material Complexity

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**Abstract:** The transdisciplinary importance of Relationships is well-established as foundational to such diverse phenomena as feedback, interconnectedness, causality, network dynamics, complexity, etc. and synonymous with connections, links, edges, interconnections, etc. Cabrera provides a formal description of and predictions *action-reaction Relationships* (R) or "R-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 7 original 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 vary for each study (ranging from N=407 to N=34,398) and are generalizeable to a normal distribution of the US population. These studies support—with *high statistical significance*—the predictions made by DSRP Theory regarding *action-reaction Relationships* 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., Distinctions, 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 *action-reaction Relationships* (R).

**Keywords:** Relationships; action-reaction; universals; cognitive complexity; systems thinking; DSRP Theory; ontological complexity; systems science

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**Citation:** Cabrera, D.; Cabrera, L.; Cabrera, E. Relationships Organize Information in Mind and Nature: Empirical Findings of Action-Reaction Relationships (R) in Cognitive and Material Complexity. *Preprints* **2021**, *1*, 0. https://doi.org/

Received:
Accepted:
Published:

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## 1. Introduction

The norm is to provide an Introduction, Methods, Results, Discussion and Conclusion for a single empirical study. In this paper, we keep to this norm but rather than share one study, we share seven. The authors could certainly have benefited from publishing seven separate papers detailing each empirical study. However, after much debate, we chose to keep the studies together as an "ecology of empirical studies." The rational for this choice is that four of 7 studies were relatively small (usually a single question) isolating a particular effect and testing a particular hypothesis. In addition, because the studies focus on specific aspects of the same phenomena (part-whole Systems Rule) the results are better understood as a whole rather than as isolated parts. We are hoping of course, that such a rationale makes sense to a systems journal. That said, the reader may read each study in isolation simply by reading section 2.1, 3.1, and 4.1 together.

### *1.1. Empirical Findings of Perspectives Across the Disciplines*

Drawing Relationships between and among entities is a concept that crosses all disciplines. The concept of Relationships goes by many names including related terms and synonyms such as: connect, relate, interconnection, interaction, link, cause, effect, affect, rank; most words with the prefixes inter-, intra-, or extra- such as interdisciplinary, intramural; between, among, couple, associate, join; most words with the the prefix co- as in correlate, cooperate or communicate; various types of relationships such as linear, nonlinear, causal, feedback, linear causality, webs of causality, etc.; and even the basic mathematical operators such as +, -, /, and x. Any time we do any of the above, we are recognizing relationships. That is, one idea or object is interrelating to another.

The ecology of 7 studies documented in this paper exist in the context of the much wider literature of empirical studies and literature reviews on relationships. There is an abundance of interest, literature, and empirical findings on relationships across the disciplinary spectrum (i.e., the physical, natural, social and applied sciences). The literature on Relationships [1–15] is well established in both the cognitive sciences and systems thinking contexts. In the cognitive sciences (as well as the physical and natural sciences) it is clear that relationships are ever present [4,8,9,12,14]. Causality (a term that refers to phenomena that is a subset of action-reaction Relationships) has been shown to be present in children [4,9,11,12,15], adults, and can be utilized as, "(...) a tool for gaining deeper understanding [14]." Cabrera [16] expanded the definition of Relationships by demonstrating that: (1) all relational processes were cases of relationships between an action and a reaction variable and (2) that action-reaction relationships were not reserved merely for 'the systems' cause and effects alone, but were structural features occurring on fractal dimensions. This critical insight—part of DSRP Theory—exposed the universality of *action-reaction Relationships* at the theoretical level. This study empirically quantifies this theoretical construct.

In a 2021 [17] review of literature, a number of empirical studies illustrate the universality of action-reaction Relationships across the disciplines [1–15,18]. It is also clear that Relationships are not enough. That they are necessary but not sufficient to explain an underlying, universal, structural grammar of cognition or to navigate the complexities of real-world systems. Empirical findings from the literature also reveal what DSRP Theory predicts: that action-reaction Relationships are integral with other universals (i.e., Distinctions, Systems, Perspectives) [19–51]. Figure 1 shows the disciplinary distribution of this research.

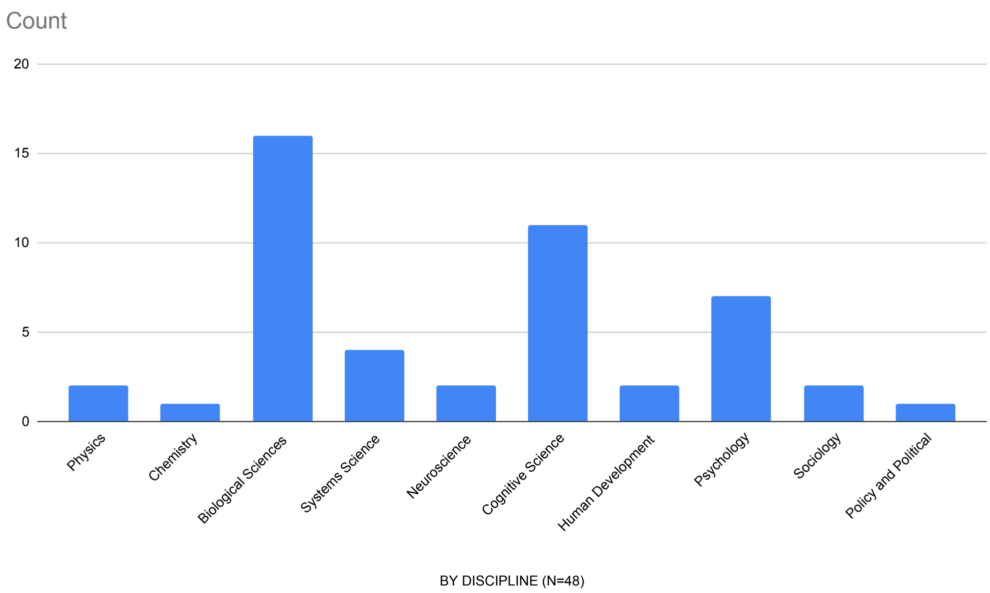



**Figure 1.** Action-reaction Relationships (R) Research Across the Disciplines

Cabrera's 2021 review of research [17] builds upon to previous literature reviews [16,52], 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 action-reaction Relationships in particular. The findings, utility, and application of action-reaction Relationships (R) are pervasive and ubiquitous. A few highlights from this literature review [17] include:

- Leonid Euler (1735) [18] solves the Konigsberg bridges problem and invents graph theory and modern day network theory based on identities (nodes) and relationships (edges);
- Norbert Wiener (1948) [2] and John Weily (1951) [1] highlight a very important structural type of relationship found within systems: feedback loops;
- Clement and Falmagne's 1986 studies [3] of how comprehension increases with interconnectivity between content knowledge;
- Gopnik et al.'s 2004 study [4] on causal structures and the causal maps of that children build to make sense of their world;
- Green's 2010 study [6] showing that memory is a function of linking thoughts to one another.; and
- Ferry et al.'s 2015 research [9] showing that infants' analogical ability is making "relational comparisons between objects, events, or ideas, and to think about relations independently of a particular set of arguments."

### 1.2. Theoretical Work on Perspectives

The simplest accurate statement of DSRP Theory is thus:

$$\text{“the ways } \overbrace{\text{information}}^{\text{that which is Organized}} \text{ is/is not } \overbrace{\text{bounded}}^{\text{Distinctions}}, \overbrace{\text{arranged}}^{\text{Systems}}, \text{ and } \overbrace{\text{interconnected}}^{\text{Relationships}} \text{ from } \overbrace{\text{frames of reference}}^{\text{Perspectives}} \text{ determines } \overbrace{\text{what actually exists}}^{\text{Material Complexity (Nature)}} \text{ and } \overbrace{\text{what we think exists}}^{\text{Cognitive Complexity (Mind)}}\text{.”}$$

DSRP Theory details quite a bit more than this simplification relays [16,52–56]. In addition, DSRP Theory has more empirical evidence supporting it than any existing systems theory (including frameworks, which are not theories) [16,17,57–66]. For more on DSRP Theory proper the reader should see the citations mentioned as this paper focuses solely on the 'R' in DSRP: Relationships.

As one of four DSRP Rules, action-reaction Relationships or R-rule is applicable across the disciplines from the physical and natural sciences to the social sciences. Their transdisciplinary importance cannot be over stated. For example, the action-reaction Relationships (R) rule is at play in physics in Newton's Third Law shown in Figure 2.

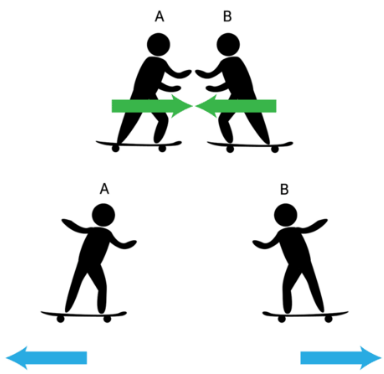



**Figure 2.** Action-Reaction Relationships (R) Rule and Newton's Third Law

This same universal structure is characterized in the concept of a feedback loop, popularized by system dynamics, where one object or idea operates on another, which in turn operates on the first shown in Figure 3.

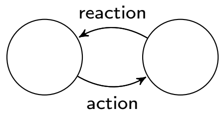



**Figure 3.** action-reaction Relationships

And, this same universal structure is useful in psychosocial applications. Figure 4 illustrates how actions and reactions form a looping process in social dynamics. Being aware (metacognitive) of these social-dynamical structures and patterns allows an individual to process *autonomic* reactions (e.g., thoughts, feelings, etc.) internally and purposefully choose one's action (outward behavior).

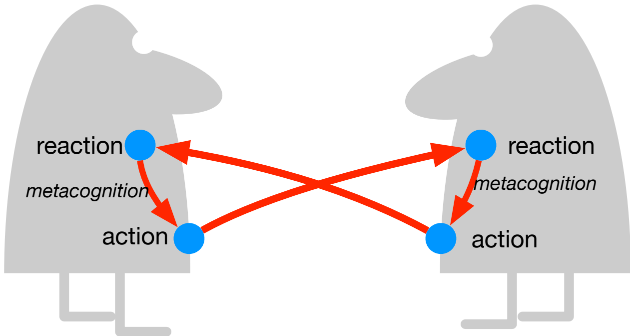



**Figure 4.** Action-Reaction Relationships (R) Rule: "R quad" Used in PsychoSocial Applications

This same relational structure provides the basis for "RDS's" (Figure 5) which stands for Relationship-Distinction-System, which help us to see that when we make a relationship between any two things or ideas, we will benefit greatly if we also (1) distinguish what that relationship is by naming it and then, (2) systematize that relationship by breaking it down into parts. RDSs are a powerful cognitive jig that allows us to see what's happening in relationships and solve all kinds of problems from complex interpersonal social dynamics in a relationship, to innovation, to solving the issue of silos in organizations.

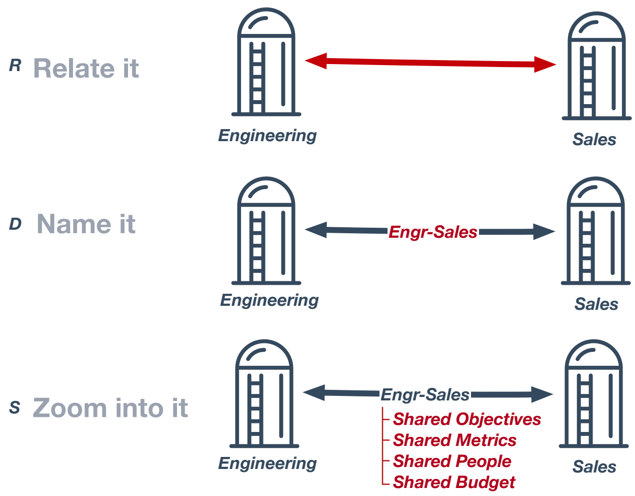


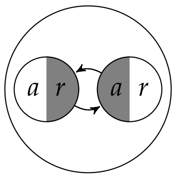

**Figure 5.** RDSs is a Powerful Cognitive Jig that Reveals the Structure of Relationships

The utility and application of action-reaction Relationships (R) is ubiquitous; there are countless more examples. Cabrera and Cabrera [16,17,51,52,67–70] expanded the transdisciplianry applicability of Relationships by detailing their internal dynamics and structures and identifying various mutual dependencies. Table 1 shows the structure of the action-reaction Relationships rule.

| $R \equiv a \Leftrightarrow r$ | A *Relationship* is defined as *action* co-implying *reaction* | | |
|---|---|---|---|
| An *action* exists | A *reaction* exists | *action* co-implies *reaction* | A *Relationship* exists |
| $a$ | $r$ | $a \Leftrightarrow r$ | $\equiv R$ |

**Table 1.** action-reaction Relationship Rule or R-rule

It is quite popular in the Systems Sciences and Systems Thinking fields, and even in quantum physics [71,72], to propose that "*it all comes down to relationships*." At the same time that DSRP Theory predicts that action-reaction Relationships (R) are universal (as well as important and applicable), it is also predicted that *Relationships are not enough* [73]. Meaning that it all doesn't come down to relationships, because Relationships are dependent on other universals. Namely, Distinctions, Systems, and Perspectives. DSRP theory comprises four dynamically interacting structures: identity-other Distinctions (D), part-whole Systems (S), action-reaction Relationships (R), and point-view Perspectives (P). Herein, we focus on point-view Perspectives (P). But, DSRP Theory also predicts that the four rules are dynamical and are necessary and sufficient. Thus, for a perspective to exist, the other rules need to be at play. Table 2 illustrates how Perspective itself, requires Distinctions, Systems, and Relationships to exist.




*Any* action-reaction **Relationship** is also:

- Two Distinctions [possible]: $\{a, \neg a\}$ and $\{r, \neg r\}$
- A Relationship ($R_r^a$): $a \underset{\text{affect}}{\overset{\text{effect}}{\Longleftrightarrow}} r$
- A System with parts: $a$, $r$, and their relationship ($R_r^a$)
- Two Perspectives [possible]: $a$ and $r$
- The Relationship itself is distinct (D), a whole with parts (S), and a Perspective (P).

**Table 2.** DSRP is Necessary and Sufficient for R-rule

### *1.3. Research Questions that Underlie the Hypotheses for R-rule Studies*

Cabrera [16] expanded on relationships theoretically by proposing in DSRP Theory that: (1) Relationships are universal to mind and nature (2) all relationships ($R$) constitute an *affect/effect* relationship between action ($a$) and reaction ($r$) variables (what Cabrera calls *elements*) and (3) that Relationships are not reserved merely connecting things but are things in and of themselves (what Cabrera calls identities). That is: any node in any network; or any element in an ecology; or any person, place, thing, or idea; has the potential to relate to others or be a relationship between others and that these relationships exist in nature (material systems) and can be taken by the human mind. DSRP Theory further stipulates that awareness of these existential relationships (metacognition of $R$-rule) can increase one's effectiveness in thinking about systems, modeling systems, or in increasing cognitive fluidity, complexity and robustness. This critical insight—part of DSRP Theory—exposed the universality of action-reaction Relationships ("R-rule") at the theoretical level. Table 1 shows the structure of the action-reaction Relationships rule according to DSRP Theory. Table 3 shows the research matrix upon which our hypotheses, null hypotheses, and research design and findings are based.

| | **Existential** *(Basic Research)* | **Efficacy** *(Applied Research)* |
| --- | --- | --- |
| **Mind** *(cognitive complexity)* | **Does DSRP Exist in 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** | |

**Table 3.** Research Questions that Underlie the Hypotheses for R-rule Studies

Thus, this set of studies on the R-rule of DSRP Theory is part of a research program that empirically tests the three major hypotheses represented 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. The following research questions are addressed in our work on all four universal patterns:

1. *Existential* (Basic research): focused on the question; Does DSRP Exist? Does DSRP exist as universal, material, observable phenomena?
2. *Efficacy* (Applied research): focused on the question; 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 question 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[1] (Figure 6).

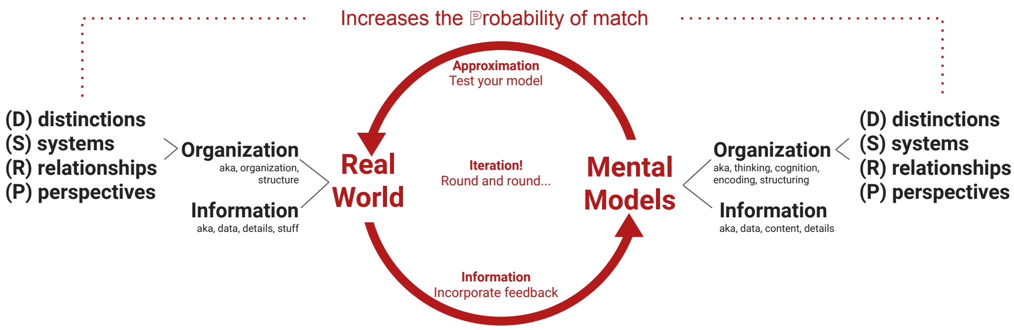



**Figure 6.** The ST/DSRP Loop

[1] 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.

The 7 studies presented herein are part of an "ecology of empirical studies" that includes multiple meta-analytical literature reviews [16,17,65] and 26 new empirical studies. The reader is directed to the other 3 collections focused on: identity-other Distinctions (D) studies [62], part-whole Systems (S) studies [64], and point-view Perspectives (P) studies [61]. The reader may want focus on this ecology of 7 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 R-rule:

1. Does the R-rule *exist* in Mind and Nature? (in the same way Evolution or Heliocentrism *exists*)
2. Does awareness (metacognition) of the R-rule *increase effectiveness* in systems thinking or cognitive complexity, fluidity, etc.?

Although the design of these research studies focused on these questions separately, there is some overlap among these studies in their results. As a general guideline, however, one is safe to conclude that the *Affective Squares*, *What Makes a Square*, *What Makes a Circle*, and *Dog-Lab-Coat* studies focused on *existential* questions and the *R-Mapping Study*, *R-STMI Study*[2], and *R-Fishtank Study* focused on *efficacy*. This ecology of studies, aims to empirically quantify the theoretical predictions made by DSRP Theory, and their various implications by showing that they are observable and significant. Specifically, that *Relationships (R) 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.;
   (b) in *nature* (i.e., physical/material, observable systems, matter, scientific findings across the disciplines, etc.);
   (c) because both mind and nature are material, Relationships are distinct material identities and part-whole Systems (e.g., RDSs); and
   (d) the basis for massively parallel action-reaction-effects in networks in both mind and nature (i.e., action-reaction relationships (R) form an $n(n-1)$ copriming[3] network where $n$ number of nodes in the network are copriming with the *other* $n-1$ nodes in the network).
2. Made up of elements (action, reaction) that are:
   (a) *co-implying* (i.e., if one exists, the other exists; called the co-implication rule);
   (b) related by a special[4] relationship: effect/affect; and
   (c) act simultaneously as, and are therefore interchangeable with, the elements of Distinctions (identity, other), Systems (part, whole) and Perspectives (point, view). This is called the simultaneity rule.
3. Mutually-dependent on identity-other Distinctions (D), part-whole Systems (S), point-view Perspectives (P) such that D, S, R, and P are both 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.

[2] STMI is the acronym for the Systems Thinking and Metacognition Inventory

[3] The terms *coprime*, *copriming*, and *coprimed* (from *co-* 'together' + prime 'to prepare') were coined in these studies to reflect the relational action-reaction effects of two or more objects (including concepts) on each other. Whereas priming is something that occurs prior to some operation, *copriming* occurs simultaneously.

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

This research empirically tests and—with highly statistically significant results—supports these specific predictions. In what follows, we present 7 empirical studies that together form an ecology of these findings.

## 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 size was chosen for generalizeability (e.g., Given Confidence Level (CL=95%), Confidence Interval (CI=5), and a US population estimated at 350,000,000, the generalizeable sample size is 384. Thus we chose sample sizes larger than this number). The sample (N varies for each study; range of N= 407 to 34,398) is generalizeable 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 22-65 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 was then collected and analyzed; note that incomplete data and/or nonsense data was removed.

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

### *2.1. The Affective Squares Study Methods*

Statistical analysis was performed using R v 3.6.3. Counts and percentages were used to summarize the distribution of categorical variables. Bar plots were used to visualize the results. Chi-square test for goodness of fit was used to assess whether the distribution of responses was not equal.

### *2.2. The What Makes a Square Study Methods*

Statistical analysis for N=406 was performed using R v 3.6.3. Counts and percentages were used to summarize the distribution of categorical variables. Bar plots were used to visualize the results. Chi-square test for goodness of fit was used to assess whether the distribution of responses was not equal. Two-null hypotheses were tested in each trial. In addition, the responses between each pair of trials were compared using Chi-square test of independence. Hypothesis testing was performed at 5% level of significance.

### *2.3. The What Makes a Circle Study Methods*

Statistical analysis for N=406 was performed using R v 3.6.3. Counts and percentages were used to summarize the distribution of categorical variables. Bar plots were used to visualize the results. Chi-square test for goodness of fit was used to assess whether the distribution of responses was not equal. For each circle, hypotheses regarding size (small, medium, and big) and alignment (center, left, and right) were tested separately. Respondents who chose more than one size or alignment for each circle were excluded from the corresponding analysis. However, the frequency of answers chosen by the respondents were visualized. Hypothesis testing was performed at 5% level of significance.

### *2.4. The Dog-Lab-Coat Study Methods*

Statistical analysis was performed using R v 3.6.3. Counts and percentages were used to summarize the distribution of categorical variables. Bar plots were used to visualize the results. McNemar's test was used to compare the distribution of responses before and after adding additional terms to the initial concept. Word clouds were used to visualize the responses. The use of various terms was compared before and after adding the additional term (dog or lab or coat). Hypothesis testing was performed at 5% level of significance.

### 2.5. *The R-Mapping Study Methods*

This study utilized data from the *Plectica Systems Mapping Software* developed by Cabrera [74]. The sample (N=34,398) consisted of a self-selecting sample of software users. Data was collected from a self-service web application that administers the Plectica software. Limited demographic data was collected. The data included all four patterns of DSRP, but the results provided herein are for the Perspective pattern only. See [75] for a report of the wider data.

### 2.6. *The R-STMI Study Methods*

This study utilized data from the *Systems Thinking and Metacognition Indicator (STMI)* developed by Cabrera and Cabrera [58]. The sample (N=1059) was a self-selecting sample of professionals between the ages of 18-65 who participated in beta version of STMI post-validation. Data was collected from a self-service web application that administers the STMI. Limited demographic data was collected. The data cuts across all four patterns of DSRP and "mix and match of DSRP patterns" on both competence and confidence measures. The results provided herein are for the Perspective pattern only. See [58] for a report of the wider data.

### 2.7. *The R-Fishtank Study Methods*

The sample (N=1,750 baseline; N=350 Post) was generalizeable to the US population (see above in general methods). The data cuts across all four patterns of DSRP. The results provided herein are for the Relationship pattern only. See [59] for a report of the wider data.

## 3. Results

### 3.1. *The Affective Squares Study Results*

Subjects (N=403) were asked to associate one of three shapes with one of three descriptions (Small, Medium, and Large Square). Table 4 shows the null and alternative hypotheses for this study.

| | | **Size** |
|---|---|---|
| Square 1 | Null | $pS = pM = pL$ |
| | Alternative | $pS \neq pM \neq pL$ |
| Square 2 | Null | $pS = pM = pL$ |
| | Alternative | $pS \neq pM \neq pL$ |
| Square 3 | Null | $pS = pM = pL$ |
| | Alternative | $pS \neq pM \neq pL$ |

**Table 4.** Null and Alternative Hypotheses for Affective Squares Study

The null hypothesis was $H_0 : S = M = L$, because if relational copriming effects *do not exist*, then one would expect that no difference would occur between the shape:name configurations; that is each of 3 shapes had an equal probability of being named each of 3 labels. The alternative hypothesis was $H_1 : S \neq M \neq L$, because if relational copriming effects *do exist*, then one would expect to see significant differences to occur between the shape:name configurations; that is each of 3 shapes has an unequal probability of being named each of 3 labels. Table 5 shows that subjects overwhelmingly used a *relationships* to distinguish the three shapes.

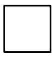
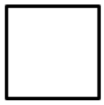
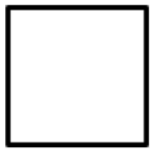
| |  |  |  |
|---|---|---|---|
| **Small Square** | 96.78% (391/403) | 0.74% (3/403) | 0.25% (1/403) |
| **Medium Square** | 2.72% (11/403) | 98.51% (398/403) | 0.25% (1/403) |
| **Large Square** | 0.25% (1/403) | 0.50% (2/403) | 99.26% (401/403) |

**Table 5.** Affective Squares Study Results Shows the Relational Nature of Distinguishing Objects

Table 6 shows statistical analyses for the responses and shows that shows high statistical significance such that we can reject the null hypotheses. In other words, copriming effects based in *relationships* do exist. Statistical analysis was performed using Chi-square G. Data was summarized using counts and percentages.

| | *N* (%) | $X^2$ | *P* | Valid *N* |
|---|---|---|---|---|
| **Small Square:** | | 735.98 | **< .001** | 403 |
| Large Square | 1 (0.25%) | | | |
| Medium Square | 11 (2.73%) | | | |
| Small Square | 391 (97.0%) | | | |
| **Medium Square:** | | 776.28 | **< .001** | 403 |
| Large Square | 2 (0.50%) | | | |
| Medium Square | 398 (98.8%) | | | |
| Small Square | 3 (0.74%) | | | |
| **Large Square:** | | 794.04 | **< .001** | 403 |
| Large Square | 401 (99.5%) | | | |
| Medium Square | 1 (0.25%) | | | |
| Small Square | 1 (0.25%) | | | |

**Table 6.** Statistical Analysis of Responses for Affective Squares Study

Additionally, Figure 7 visually represents the overwhelming majority (97-99.5%) of respondents distinguished objects based on their relationships to one another.

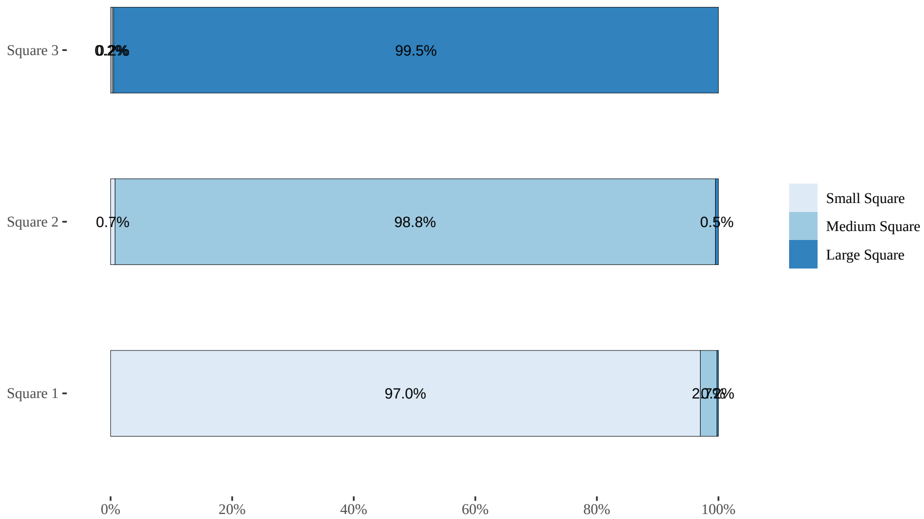
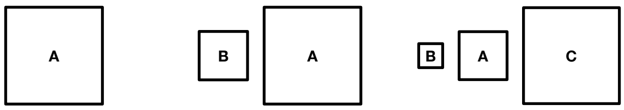



**Figure 7.** Majority Distinguish Objects Based on Relationships

### *3.2. The What Makes a Square? Study Results*

In the first task of three, subjects (N=406) were asked to identify a shape labelled 'A' and given the following response choices: square, small square, medium square, and large square. Completion of the first task established a baseline because any answer could be 'correct'-given that the *uncontextualized* (no relational copriming) square could be considered a square or as a small, medium, or large square. In the second and third tasks, the shape labelled 'A' was put next to a copriming shape labelled 'B' and in the third task two relational copriming shapes labelled 'B' and 'C.' Table 7 shows the alternative and null hypotheses for this study.




| | Task 1 | Task 2 | Task 3 |
|---|---|---|---|
| **Null 1** | $p1 = p2 = p3 = p4$ | $p1 = p2 = p3 = p4$ | $p1 = p2 = p3 = p4$ |
| **Alternative 1** | $p1 \neq p2 \neq p3 \neq p4$ | $p1 \neq p2 \neq p3 \neq p4$ | $p1 \neq p2 \neq p3 \neq p4$ |
| **Null 2** | | $p4 = 100\%$ | $p3 = 100\%$ |
| **Alternative 2** | | $p4 \neq 100\%$ | $p3 \neq 100\%$ |

$p1 = p$ square, $p2 = p$ small square, $p3 = p$ medium square, $p4 = p$ large square

**Table 7.** Hypotheses for What Makes a Square? Study

Two null hypotheses—$H_{0_1} : p1 = p2 = p3 = p4$ and $H_{0_2} : p4 = 100; p3 = 100$—were tested, because if relational copriming effects *do not exist*, then one would expect no change to occur between the baseline and the second and third tasks (e.g. responses are completely independent of one another). The alternative hypothesis for Task 2 was $H_{a_1} : p1 \neq p2 \neq p3 \neq p4$, because if relational copriming effects *do exist*, then one would expect significant change (difference) to occur between the baseline and the second and third tasks (i.e., probability of answers are not equal). Likewise, the alternative hypothesis for Task 2 and 3 was $H_{a2} : p4 \neq 100; p3 \neq 100\%$.

In Task 1, subjects were asked to drag one of four responses to identify a shape labelled 'A.' Table 8 shows that 55.17% (224/406) of subjects chose square. The remaining responses were spread across small square 3.69% (15/406), medium square 14.77% (60/406), and large square 26.35% (107/406).

In Task 2, subjects where asked to identify a shape labelled 'A' that was visually placed next to another smaller shape labelled 'B.' The same answer choices were available: square, small square, medium square, and large square. In this case, large square was the chosen response at 75.36% (see Table 8), indicating the relational influence of the box 'B' on the answer choice.

In Task 3, subjects (N=406) were then asked to identify a shape labelled 'A' that was placed between a smaller shape labelled 'B' and a larger shape labelled 'C.' The same choices were available: square, small square, medium square, and large square. In this case, 81.77% or 332/406 chose medium square (as shown in Table 8).

| | Square | Small Square | Medium Square | Large Square |
|---|---|---|---|---|
| **Task 1** | **55.17%** (224/406) | 3.69% (15/406) | 14.77% (60/406) | 26.35% (107/406) |
| **Task 2** | 6.89% (28/406) | 9.11% (37/406) | 8.62% (35/406) | **75.36%** (306/406) |
| **Task 3** | 3.44% (14/406) | 4.43% (18/406) | **81.77%** (332/406) | 10.34% (42/406) |

**Table 8.** Data for Tasks 1, 2, and 3—Relative Squares

Table 9 shows the hypotheses-testing results for all three tasks. The null hypotheses are rejected for all three tasks with high statistical significance.

| | Task 1 | Task 2 | Task 3 |
|---|---|---|---|
| **H1** | $X^2$ (3) = 239; P**<.001** | $X^2$ (3) = 550; P**<.001** | $X^2$ (3) = 702; P**<.001** |
| **H2** | | $X^2$ (1) = 2290; P**<.001** | $X^2$ (1) = 1217; P**<.001** |

**Table 9.** Hypothesis Testing Results for What Makes a Square? Study

Table 10 shows the pairwise comparisons for the different tasks. Not that P-values were adjusted for pairwise comparisons, and we see highly statistically significant effects in each pair.

| | *P* |
|---|---|
| Task 1 : Task 2 | **<.001** |
| Task 1 : Task 3 | **<.001** |
| Task 2: Task 3 | **<.001** |

**Table 10.** Pairwise Comparison of Tasks

Additionally, Figure 8 visually represents the distribution of responses for each task objects.

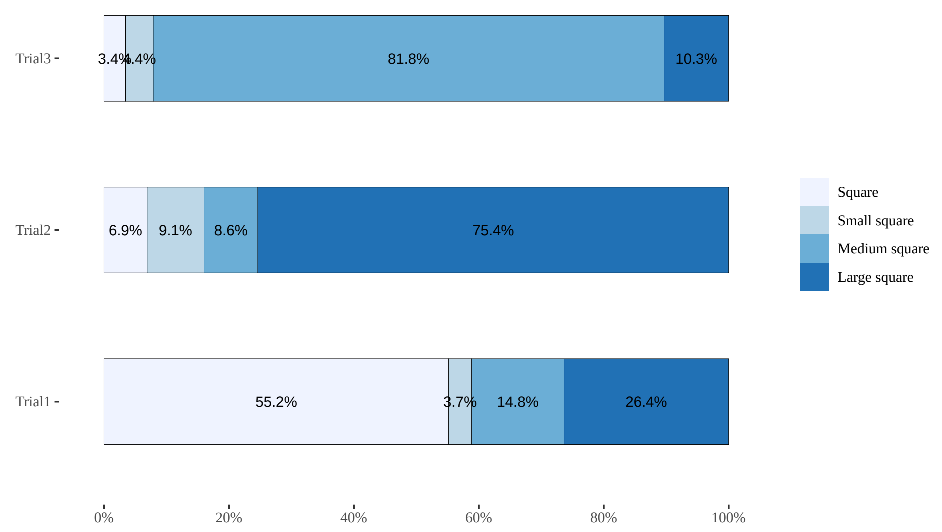



**Figure 8.** Distribution of responses

Results showed that 55.2% chose "square" as a response to the first question. When another small square was added, three-quarters of the respondents chose "Large square". When two additional squares were added (one smaller and one larger than the target square), 81.8% of the respondents chose "Medium square".

### *3.3. The What Makes a Circle? Study Results*

Subjects (N=381) were shown three different sized circles presented from left (smallest) to right (largest) as shown in Figure 9. They were asked to identify whether each circle was: Left, Center, Right, Large, Medium, or Small and instructed to 'select all that define each item.'

**Figure 9.** The 'What Makes a Circle?' Task

We tested six null hypotheses (2 hypotheses x 3 circles). For each circle, two hypotheses were tested (one for size and one for alignment).

| | | **Size** | **Alignment** |
|---|---|---|---|
| **Circle 1** | Null | $pS = pM = pL$ | $pL = pC = pR$ |
| | Alternative | $pS \neq pM \neq pL$ | $pL \neq pC \neq pR$ |
| **Circle 2** | Null | $pS = pM = pL$ | $pL = pC = pR$ |
| | Alternative | $pS \neq pM \neq pL$ | $pL \neq pC \neq pR$ |
| **Circle 3** | Null | $pS = pM = pL$ | $pL = pC = pR$ |
| | Alternative | $pS \neq pM \neq pL$ | $pL \neq pC \neq pR$ |

**Table 11.** Hypotheses for What Makes a Square? Study

Figure 10 shows results for all three circles in terms of size. Results showed that 85% of the respondents chose only one response for the size and 2-5% of the respondents chose 2 answers.

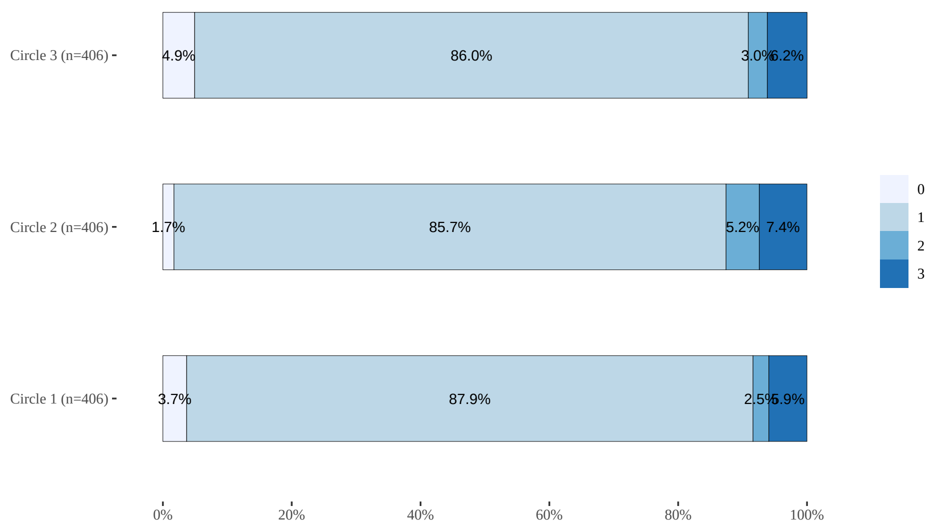



**Figure 10.** Number of Size-Responses Chosen by Respondents for Each Circle

Figure 11 shows results (for respondents who only chose 1 response) for all three circles in terms of size. Results showed that 96% of the respondents perceived circle 1 as small, circle 2 as medium, circle 3 as big.

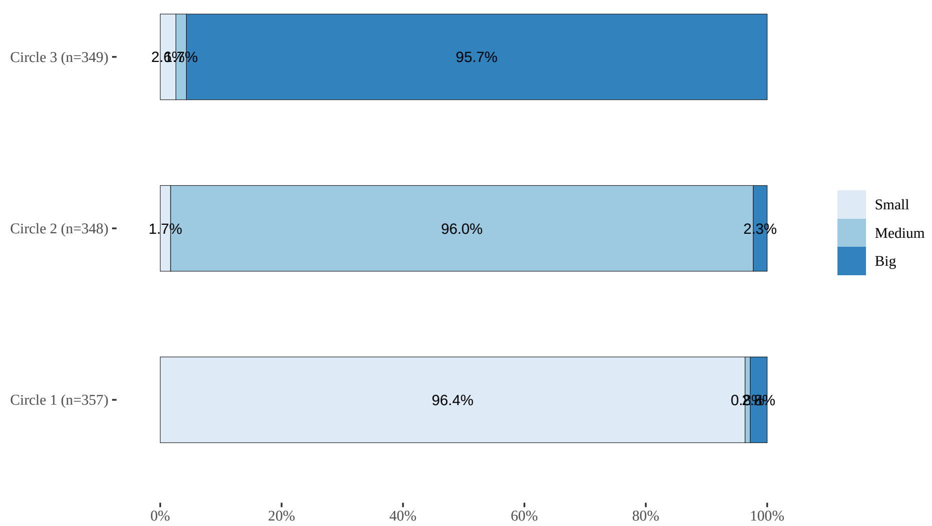



**Figure 11.** Size of the Circle Chosen by Respondents (who chose 1 response)

Table 12 provides hypotheses-testing results for size choices for all three circles. The observed probability was significantly different from the expected equal probabilities (33%) under the null hypothesis for all three circles ($P < .001^{**}$).

| | pS | pM | pL | $X^2$ | P |
|---|---|---|---|---|---|
| **Circle 1** | 344 (96.4%) | 3 (0.84%) | 10 (2.80%) | 858.53 | < **.001** |
| **Circle 2** | 6 (1.72%) | 334 (96.0%) | 8 (2.30%) | 800.84 | < **.001** |
| **Circle 3** | 9 (2.58%) | 6 (1.72%) | 334 (95.7%) | 805.53 | < **.001** |

Analysis was restricted to respondents who chose only 1 answer

**Table 12.** Hypotheses testing for size

Figure 12 shows the results for relative alignment of circles (i.e., whether they are left, center, or right). Results showed that 30.5% chose two answers for circle 3. For circle 1, 83.5% chose 1 answer and 5.4% chose two answers. For circle 2, 10% chose two answers.

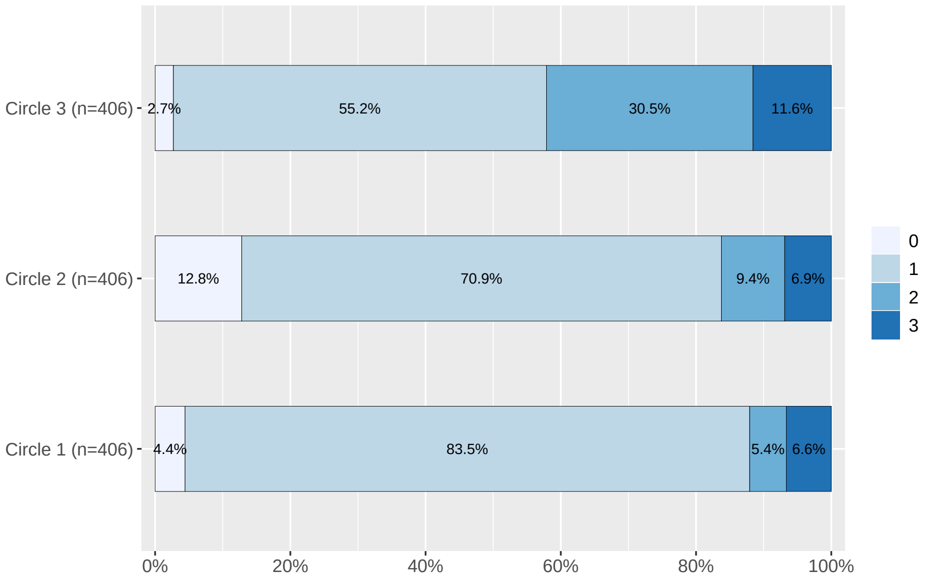



**Figure 12.** Number of Responses Chosen by Respondents for Circle-Alignment

Table 13 shows detailed breakdowns of the various responses for Circle 3's alignment. This detail was necessary due to the 'anomalous' results for Circle 3. Of particular interest was that 37% who distinguished Circle 3 as being the "Center Circle." A total of 124 respondents chose two answers for circle 3. Of these, 106 chose "center" and "right".

| Circle 3 Left | Circle 3 Center | Circle 3 Right | *n* |
|---|---|---|---|
| NO | NO | NO | 11 |
| NO | NO | YES | 197 |
| NO | YES | NO | 17 |
| NO | YES | YES | 106 |
| YES | NO | NO | 10 |
| YES | NO | YES | 14 |
| YES | YES | NO | 4 |
| YES | YES | YES | 47 |

**Table 13.** Responses for circle 3 (analysis restricted to respondents who chose two answers)

Figure 13 shows that 97% of the respondents chose “left” for circle 1. Regarding circle 2, 25% of the respondents chose “left” and 67% chose “center” while 6.9% chose “right”. For circle 3, 10% chose “left” and “center”.

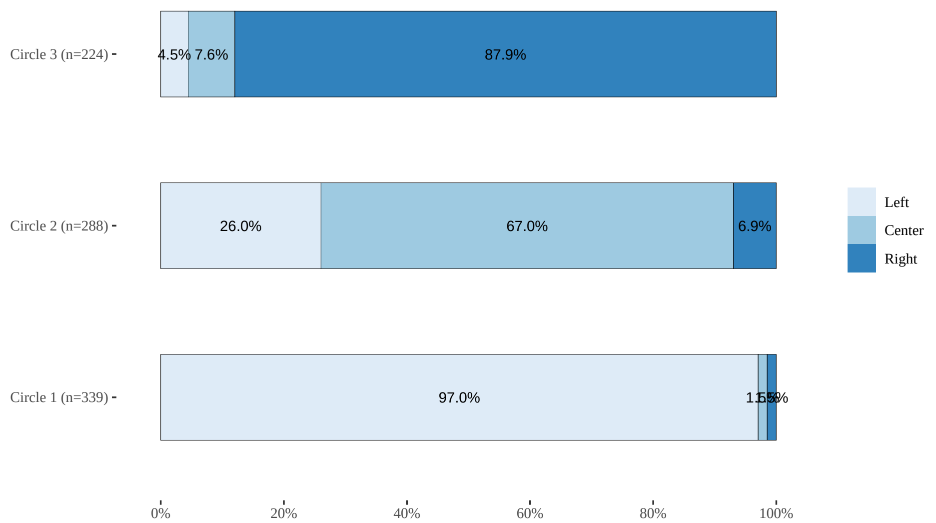



**Figure 13.** Perceived alignment of the three circles (analysis was restricted to respondents who chose 1 answer)

Table 14 shows statistical analyses of hypotheses relative to alignment. Analysis was restricted to respondents who chose only 1 answer.

| | pL | pC | pR | $X^2$ | P |
|---|---|---|---|---|---|
| Circle 1 | 329 (97.1%) | 5 (1.47%) | 5 (1.47%) | 619.33 | **< .001** |
| Circle 2 | 75 (26%) | 193 (67%) | 20 (6.94%) | 162.77 | **< .001** |
| Circle 3 | 10 (4.46%) | 17 (7.59%) | 197 (87.9%) | 300.97 | **< .001** |

**Table 14.** Hypotheses Testing for Alignment

Results showed that the observed probabilities were significantly different from what was expected under the null hypothesis for all three circles (P<.001**).

| | [ALL] N=406 | N |
|---|---|---|
| **Alignment** | | |
| **Small Circle** | | 406 |
| Left | 377 (92.9%) | 406 |
| Center | 38 (9.36%) | 406 |
| Right | 49 (12.1%) | 406 |
| **Medium Circle** | | 406 |
| Left | 138 (34.0 | 406 |
| Center | 252 (62.1%) | 406 |
| Right | 58 (14.3%) | 406 |
| **Large Circle** | | 406 |
| Left | 75 (18.5%) | 406 |
| Center | 174 (42.9%) | 406 |
| Right | 364 (89.7%) | 406 |
| **Size** | | |
| **Small Circle** | | 406 |
| Big | 40 (9.85%) | 406 |
| Medium | 33 (8.13%) | 406 |
| Small | 376 (92.6%) | 406 |
| **Medium Circle** | | 406 |
| Big | 56 (13.8%) | 406 |
| Medium | 383 (94.3%) | 406 |
| Small | 41 (10.1%) | 406 |
| **Large Circle** | | 406 |
| Big | 367 (90.4%) | 406 |
| Medium | 40 (9.85%) | 406 |
| Small | 41 (10.1%) | 406 |

**Table 15.** All respondents

| Circle | N (%) | Valid n |
|---|---|---|
| Circle 1: | | 357 |
| Small | 344 (96.4%) | |
| Medium | 3 (0.84%) | |
| Big | 10 (2.80%) | |
| Circle 2: | | 348 |
| Small | 6 (1.72%) | |
| Medium | 334 (96.0%) | |
| Big | 8 (2.30%) | |
| Circle 3: | | 349 |
| Small | 9 (2.58%) | |
| Medium | 6 (1.72%) | |
| Big | 334 (95.7%) | |
| Circle 1: | | 339 |
| Left | 329 (97.1%) | |
| Center | 5 (1.47%) | |
| Right | 5 (1.47%) | |
| Circle 2: | | 288 |
| Left | 75 (26.0%) | |
| Center | 193 (67.0%) | |
| Right | 20 (6.94%) | |
| Circle 3: | | 224 |
| Left | 10 (4.46%) | |
| Center | 17 (7.59%) | |
| Right | 197 (87.9%) | |

**Table 16.** Respondents with only one choice

### *3.4. The Dog-Lab-Coat Study Results*

The null hypothesis was $H_0 : p = 0$, because if relational copriming effects *do not exist*, then one would expect that no difference would occur between the the first and second answer choice; that the probability that a description of X (i.e, each of the 3 terms: DOG, LAB, and COAT) changes when paired with another of these terms is 0. The alternative hypothesis was $H_1 : p > 0$, because if relational copriming effects *do exist*, then one would expect that a difference *would* occur between the the first and second answer choice; that the probability that a description of X (i.e, each of the 3 terms: DOG, LAB, and COAT) changes when paired with another of these terms is >0.

Subjects (N=366)[5] were asked a set of questions to determine the degree to which cognition relies on action-reaction Relationships among ideas or concepts. Subjects were first asked to describe in their words what they thought about when thinking about five things: Dog, Tree, Coat, Snow, and Lab. Tree and Snow were distractions used to ensure that Dog, Lab, and Coat in the baseline would not be affected. This technique was tested in prior research to verify its effectiveness. Subsequently, the data for Tree and Snow were deemed irrelevant to the study and are not provided herein.

Subjects' unique results were cleaned by removing obvious misspellings and ignoring capitalization. For example, if a subject said "White Coat" and another said, "white coat" and another said "Wite caot" these three entries would be counted as 1 unique entry. Responses were open ended, with no minimum or maximum length, and coded into similar terms. Descriptions provided by subjects for DOG were coded into 106 unique coded tags. LAB descriptions yielded 66 unique coded tags. Descriptions of COAT were coded into 39 unique tags. For coding/tagging purposes, answers that were obvious *Nonsense*, answers that provided a *Literal* response such as 'the word coat,' and *Other* responses the meaning of which could not be determined, were removed from the analysis.

Counts for each unique coded-tag were calculated and used to create a word cloud[6] for visual comparison to provide both a quantitative and qualitative view of the data to capture its richness. This provided a realistic picture of the meaning behind subject answers, shown in Table 17 for the baseline descriptions of DOG, COAT, and LAB. The combination of data and visual comparison makes the copriming effects of action-reaction Relationships quite stark.

| Describe DOG | Describe COAT | Describe LAB |
|---|---|---|


**Table 17.** Word Clouds of Un-coprimed DOG, COAT, and LAB Baseline Concepts

The data used to generate the word clouds is shown in Table 18, which shows that the 'concepts' behind the descriptions of un-coprimed items are relatively typical. For example, a DOG (un-coprimed) is an animal with 4 legs including many breeds, some small, furry, barking, big, pets, cute, and white. A COAT is warm, for winter/cold, black or brown, clothing that can be worn and is comfortable. And a LAB is a laboratory for science and experiments, used by scientists for chemistry with beakers, test-tubes, etc.

[5] number of subjects varied by task
[6] Used R v3.6.3. and wordclouds.com

| Dog | | | Coat | | | Lab | | |
|---|---|---|---|---|---|---|---|---|
| Coded-Term (>1%) | % of Total | Freq. | Coded-Term (>1%) | % of Total | Freq. | Coded-Term (>1%) | % of Total | Freq. |
| animal | 8.83% | 40 | Warm | 27.25% | 100 | laboratory | 28.76% | 132 |
| 4-legs | 6.84% | 31 | Winter/Cold | 7.63% | 28 | science | 11.98% | 55 |
| breed | 6.84% | 31 | Black | 5.99% | 22 | experiments | 6.32% | 29 |
| small | 6.18% | 28 | Clothing | 5.18% | 19 | scientists | 5.23% | 24 |
| brown | 4.64% | 21 | Size | 4.90% | 18 | chemistry | 4.58% | 21 |
| furry | 4.19% | 19 | Leather | 4.09% | 15 | clean | 3.92% | 18 |
| bark | 3.75% | 17 | Buttons/Zippers | 3.81% | 14 | beakers | 3.70% | 17 |
| big | 3.53% | 16 | Fur | 3.81% | 14 | labrador | 3.49% | 16 |
| pet | 3.53% | 16 | Wearing | 3.54% | 13 | test-tubes | 3.05% | 14 |
| cute | 3.31% | 15 | Comfortable | 2.72% | 10 | sterile | 2.18% | 10 |
| white | 3.09% | 14 | Brown | 2.45% | 9 | equipment | 1.96% | 9 |
| fluffy | 2.65% | 12 | Green/Blue | 2.45% | 9 | medicine | 1.96% | 9 |
| fur | 2.21% | 10 | Long | 2.45% | 9 | labcoats | 1.74% | 8 |
| hair | 2.21% | 10 | Purple/Pink | 2.18% | 8 | research | 1.53% | 7 |
| black | 1.99% | 9 | Fluffy/Fuzzy | 1.91% | 7 | technology | 1.31% | 6 |
| tail | 1.99% | 9 | Hood | 1.91% | 7 | scientific | 1.09% | 5 |
| best-friend | 1.32% | 6 | Heavy | 1.63% | 6 | testing | 1.09% | 5 |
| golden-retriever | 1.32% | 6 | Jacket | 1.63% | 6 | | | |
| medium-sized | 1.32% | 6 | Brand | 1.36% | 5 | | | |
| friendly | 1.10% | 5 | Long-Sleeved | 1.36% | 5 | | | |
| | | | Red | 1.36% | 5 | | | |
| | | | Insulated | 1.09% | 4 | | | |
| | | | Protective | 1.09% | 4 | | | |
| | | | Wool | 1.09% | 4 | | | |

**Table 18.** Coded-tags for Un-coprimed DOG, COAT, and LAB

Once a baseline of concepts was established, subjects were then asked a set of four 'coprimed questions' in which they were given two words from the three (DOG, LAB, COAT) in boxes and then asked to describe one of the words. We call this '*copriming*' because, provided at the same time, each word has a *simultaneous* priming effect on the other. Thus the hypothesis that when copriming occurs, the conceptualization, meaning, and description of either one of the words will vary as a result of its copriming twin. For COAT-LAB coprimed COAT there were 24 coded tags. For DOG-LAB coprimed LAB there were 73 coded tags. For COAT-LAB coprimed LAB there were 75 coded tags. For DOG-COAT coprimed COAT there were 55 coded tags. In addition, for each coprime study, a binary comparison was made using text analysis and coding by three researchers to determine if responses were, respectively, 'COAT or DOG or LAB-like' (1) or not (0). These binary comparisons were used to determine the correlation coefficients, p-value, standard deviations, and averages.

#### 3.4.1. Given COAT and LAB, Describe COAT

First, they were presented with the coprimed task: Given COAT and LAB, describe COAT. The word cloud in Table 19 visually illustrates what the data in Table 20 reveals: whereas subjects described a stereotypical 'winter' or 'warm' (34.88% of the time) and 'black, brown or red' (9.8% of the time) COAT in the baseline measure, they were more likely to describe the COAT as 'white or blue' (13.23%) and 'labcoat' (28.40%) when the copriming took place.

From both the quantitative data and the visual word clouds one can see that when Subjects described only COAT, they predominantly described a jacket or winter-style coat. But when coprimed with COAT and LAB together, they describe COAT as being both a winter, warm, jacket-style coat but a significant number of subjects also describe COAT as a white (or blue), scientists' or doctors' lab coat. This illustrates that the meaning of LAB has a LAB-like action on the meaning of COAT (and vice versa), thereby causing a significant number of subjects to describe the coat as a lab coat or include other scientific types of concepts.

In other words, the concept LAB changed the concept of COAT (and likely vice versa). Instead of a warm winter coat, more subjects thought of a white lab coat. Some subjects' responses included embodied stories that emerged just from the copriming. These include examples such as: 'You take your coat off and go into the lab;' 'The scientist had to put on his hazmat coat before entering the lab;' 'It's a coat made from a dog;' and 'The coat keeps you as warm as the dog.' These stories reinforce the cognitive tendency when given two or more objects or concepts, to identify the relationship between them, even to go so far as to invent one where none exists.

| **Describe COAT.** | **coprimed with COAT and LAB, Describe COAT.** |
|---|---|
|  |  |





**Table 19.** Comparison of Un-coprimed COAT to COAT-LAB coprimed COAT.

| **Coded terms (>1%)** | **Percent of Total** | **Frequency** |
|---|---|---|
| lab coat | 28.40% | 73 |
| winter/warm | 26.46% | 68 |
| clothing | 11.67% | 30 |
| white | 10.51% | 27 |
| fur | 3.50% | 9 |
| leather | 3.11% | 8 |
| size | 2.72% | 7 |
| white/blue | 2.72% | 7 |
| action | 1.56% | 4 |
| science | 1.56% | 4 |
| brown/black/grey/pink | 1.17% | 3 |

**Table 20.** Coded-tags for COAT-LAB coprimed COAT

| **DOG-like** | **No** | **Yes** | $X^2$ | $P$ |
|---|---|---|---|---|
| | **Before** | | | |
| | N=202 | N=1 | | |
| | **After** | | | |
| | | | 88.1 | **<.001** |
| No | 112 (55.4%) | 1 (100%) | | |
| Yes | 90 (44.6%) | 0 (0.00%) | | |

**Table 21.** Comparison of terms before and after adding the word LAB to COAT

A total of 203 respondents were included in the LAB-COAT study. McNemar's test result was statistically significant, indicating a statistically significant change in responses before and after including the word LAB. Before including LAB, only one respondents used lab-like answer compared to 202 who did not. Of the 202 who did not, 44.6% used lab-like answers after adding the word LAB to the original word COAT (P<.001***).

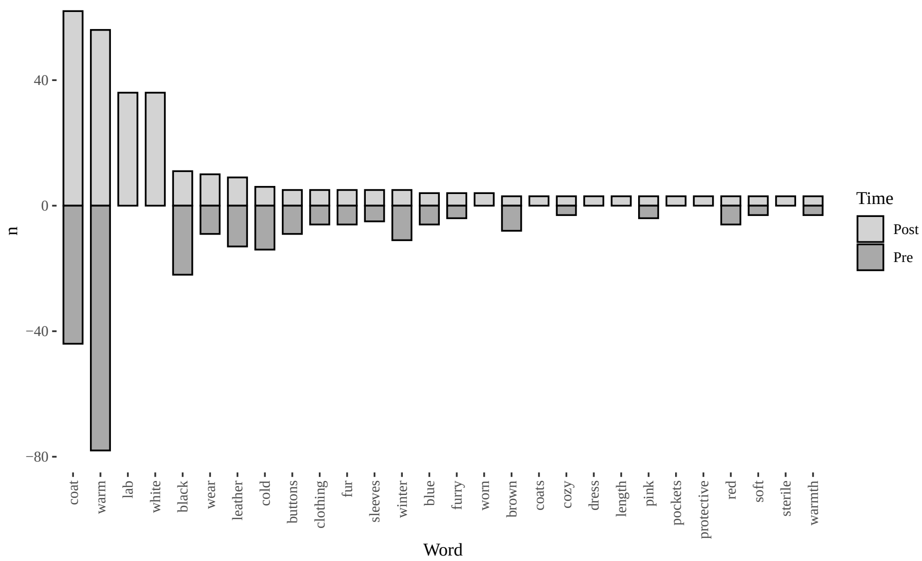



**Figure 14.** Comparison of word frequency before and after adding the word LAB in the LAB-COAT task

Figure 14, compares the frequency of words used before and after. You can see that specifically, *lab* (as in '*labcoat*') and *white* were more frequent descriptors of the COAT after whereas *warm* and *black* were more frequent before.

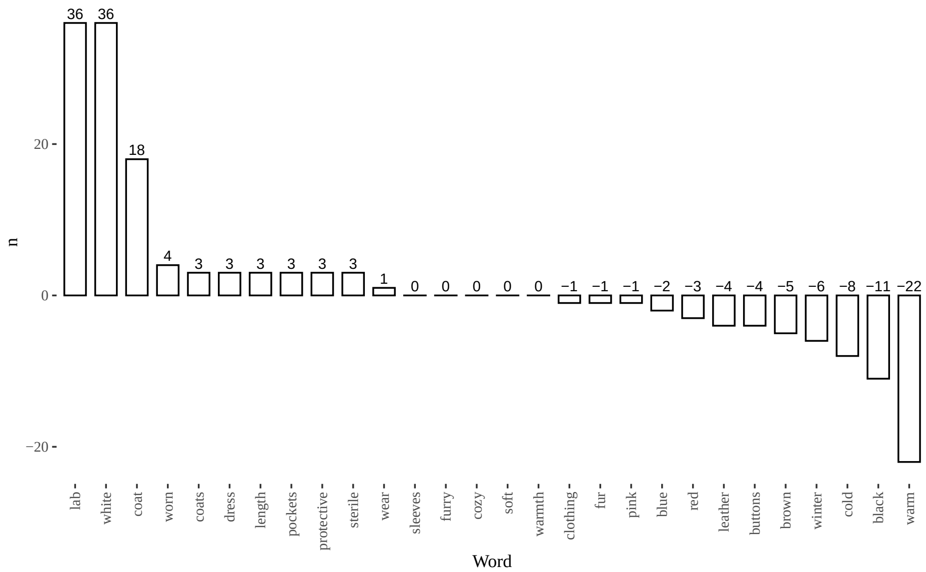



**Figure 15.** The difference in the frequency of use of words before and after adding the word LAB

Figure 15, shows the difference in frequency of words used before and after. Positive numbers indicate more frequent use *after* adding the word LAB, and negative numbers indicate more frequent use *before* adding LAB. For example, warm was used for the description of COAT 22 times more before and lab and coat were used to describe COAT 36 times more after.

The null hypothesis ($H_0$) that "Subjects answers show no lab-like change as a result of coprime" and an alternative Hypothesis ($H_a$) that "Participant answers show lab-like change as a result of the coprime" were tested. The unprimed COAT sample (N=203) had 1 or 0.4% 'lab-like' responses. Whereas, the COAT-LAB coprime for the COAT sample (N=203) had 90 or 44.6% 'lab-like' responses. We found a statistically highly significant relationship between copriming and results. Thus, $H_0$ is rejected and $H_a$ is supported: "Participant answers show a lab-like change as a result of the coprime" indicating that action-reaction Relationships between objects and concepts exist. [7]

### 3.4.2. Given DOG and LAB, Describe LAB

Second, subjects were presented with the following prompt: Given DOG and LAB, describe LAB.

**Describe LAB.**


**coprimed with DOG and LAB, Describe LAB.**


**Table 22.** Comparison of Unprimed LAB to DOG-LAB coprimed LAB.

In simple terms, the word cloud in Table 22 shows what the data in Table 23 reveals: when subjects described a stereotypical 'scientists' (5.23%) or 'science' (11.98%) 'laboratory' (28.76%) for LAB in the baseline measure, they were significantly more likely to describe the LAB as 'labrador' (17%) and 'dog-in-a-laboratory,' (3.8%) or 'veterinary lab' (3.5%) or 'chocolate' when the copriming took place.

In some cases, subjects created miniature stories such as "Where experiments are done on dogs :( " or "Oh poor dog. Hopefully they aren't doing tests on him" or "The veterinarian examined the dog in her lab," or our favorite, "A science lab where the dog runs experiments." In these cases, the interaction effects of DOG and LAB are obvious, and quite palpably different—both quantitatively and qualitatively—from the responses for DOG or LAB alone.

[7] The possibility of mediating variables in particular demographics of subjects was ruled out using contingency tables to cross tabulate the data by age, race, gender, ethnicity, and education level.

| Coded terms (>1%) | Percent of Total | Frequency |
|---|---|---|
| laboratory | 29.3% | 117 |
| labrador | 17.0% | 68 |
| science | 4.5% | 18 |
| dog-in-a-laboratory | 3.8% | 15 |
| veterinary-lab | 3.5% | 14 |
| black | 2.3% | 9 |
| chemistry | 2.3% | 9 |
| size | 2.3% | 9 |
| experiments | 2.0% | 8 |
| clean | 1.8% | 7 |
| equipment | 1.8% | 7 |
| medicine | 1.8% | 7 |
| scientists | 1.8% | 7 |
| tests | 1.8% | 7 |
| brown | 1.5% | 6 |
| animal-testing | 1.3% | 5 |
| research | 1.3% | 5 |

**Table 23.** Coded-tags for Given DOG-LAB, Describe LAB.

| DOG-like | No | Yes | $X^2$ | *P* |
|---|---|---|---|---|
| | **Before** | | | |
| | N=181 | N=14 | | |
| | **After** | | | |
| | | | 83 | **<.001** |
| No | 96 (53.0%) | 0 (0.00%) | | |
| Yes | 85 (47.0%) | 0 (100%) | | |

**Table 24.** Comparison of terms before and after adding the word DOG to LAB

A total of 195 subjects were included in the DOG-LAB study. McNemar's test result was statistically significant, indicating a statistically significant change in responses before and after including the word DOG. Before including DOG, fourteen respondents used dog-like answers compared to 181 who did not. Of the 181 who did not, 47% used dog-like answers after adding the word DOG to the original word "lab" (P<.001***).

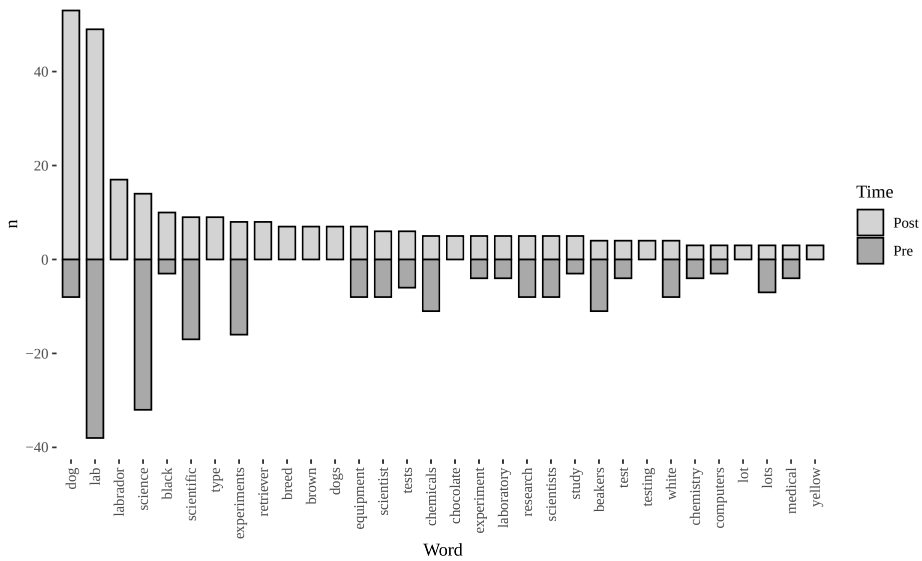



**Figure 16.** Comparison of word frequency before and after adding the word DOG in the DOG-LAB task

Figure 16, compares the frequency of words used before and after. One can see that *dog* and *labrador* were more frequent descriptors of the LAB after whereas *science* and *experiments* were more frequent before.

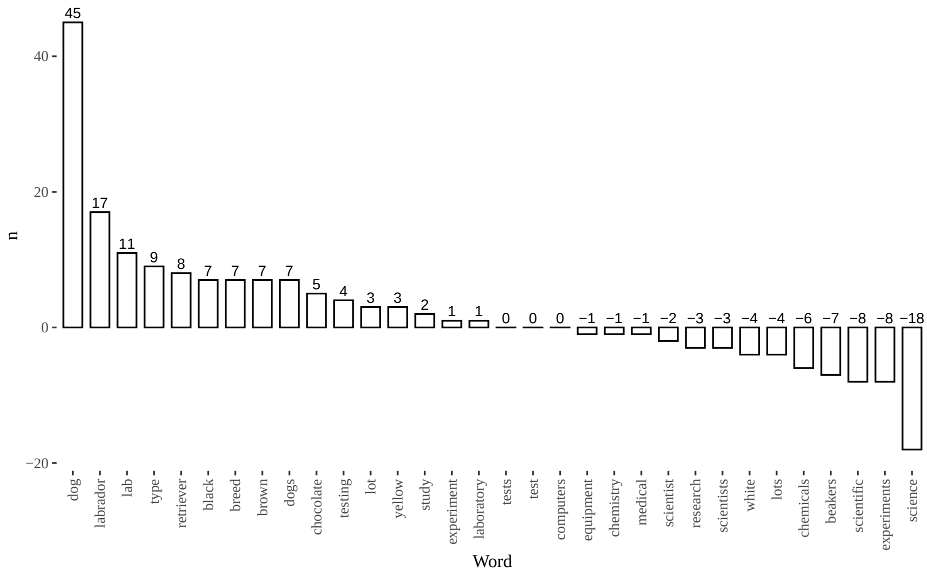



**Figure 17.** The difference in the frequency of use of words before and after adding the word DOG

Figure 17, shows the difference in frequency of words used before and after. Positive numbers indicate more frequent use *after* adding the word LAB, and negative numbers indicate more frequent use *before* adding DOG. For example, *dog* was used for the description of LAB 45 times more after and *science* and *experiments* were used to describe LAB 18 and 8 times more, respectively, before.

The null hypothesis ($H_0$) that "Subjects answers show no dog-like change as a result of coprime" and an alternative Hypothesis ($H_a$) that "Participant answers show dog-like change as a result of the coprime" were tested. We found a statistically highly significant relationship between copriming and affected results. Thus, $H_0$ is rejected and $H_a$

is supported: "Participant answers show dog-like change as a result of the coprime" or action-reaction Relationships between objects and concepts exist[8].

3.4.3. Given COAT and LAB, Describe LAB

Third, respondents were presented with: Given COAT and LAB, describe LAB.

**Describe LAB.**


**Coprimed with COAT and LAB, Describe LAB.**

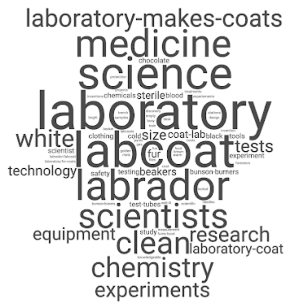



**Table 25.** Comparison of Unprimed LAB to COAT-LAB Coprimed LAB.

In simple terms, the word cloud in Table 25 shows what the data in Table 26 reveals: when subjects described a stereotypical 'scientists' (5.23%) or 'science' (11.98%) 'laboratory' (28.76%) for LAB in the baseline measure, they were significantly more likely to include 'lab coat,' (11.9%) etc. in their description LAB when the copriming took place.

| Coded terms (>1%) | Percent of Total | Frequency |
|---|---|---|
| laboratory | 34.58% | 139 |
| lab coat | 11.19% | 45 |
| science | 7.21% | 29 |
| labrador | 3.23% | 13 |
| medicine | 2.74% | 11 |
| scientists | 2.49% | 10 |
| chemistry | 2.24% | 9 |
| clean | 2.24% | 9 |
| white | 1.99% | 8 |
| experiments | 1.74% | 7 |
| laboratory-makes-coats | 1.74% | 7 |
| research | 1.74% | 7 |
| equipment | 1.49% | 6 |
| size | 1.49% | 6 |
| tests | 1.49% | 6 |
| beakers | 1.00% | 4 |
| fur | 1.00% | 4 |
| laboratory-coat | 1.00% | 4 |
| technology | 1.00% | 4 |

**Table 26.** Coded-tags for COAT-LAB Coprimed LAB.

[8] The possibility of mediating variables in particular demographics of subjects was ruled out using contingency tables to cross tabulate the data by age, race, gender, ethnicity, and education level.

| COAT-like | No | Yes | $X^2$ | $P$ |
|---|---|---|---|---|
| | **Before** | | | |
| | N=195 | N=7 | | |
| | **After** | | | |
| | | | 50.42 | **<.001** |
| No | 137 (70.3%) | 2 (28.6%) | | |
| Yes | 58 (29.7%) | 5 (71.4%) | | |

**Table 27.** Comparison of terms before and after adding the word COAT to LAB

A total of 202 respondents were included in the COAT-LAB study. McNemar's test result was statistically significant, indicating a statistically significant change in responses before and after including the word COAT. Before including COAT, only seven respondents used coat-like answers compared to 195 who did not. Of the 195 who did not, 29.7% used coat-like answers after adding the word COAT to the original word "lab" (P<.001***).

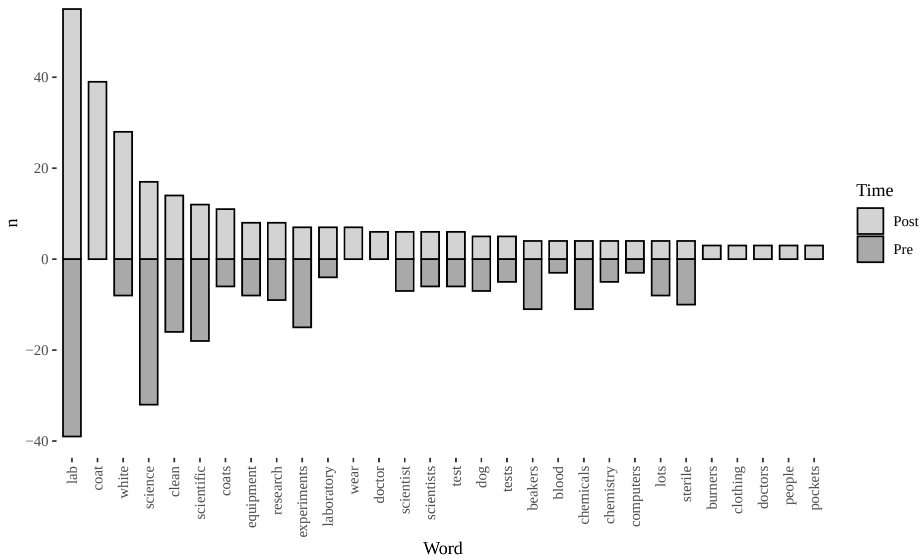



**Figure 18.** Comparison of frequency of words used to describe LAB before and after for Given COAT-LAB, Describe LAB task

Figure 18, compares the frequency of words used before and after. One can see that *coat* and *white* were more frequent descriptors of LAB after whereas *science* and *scientific* were more frequent before.

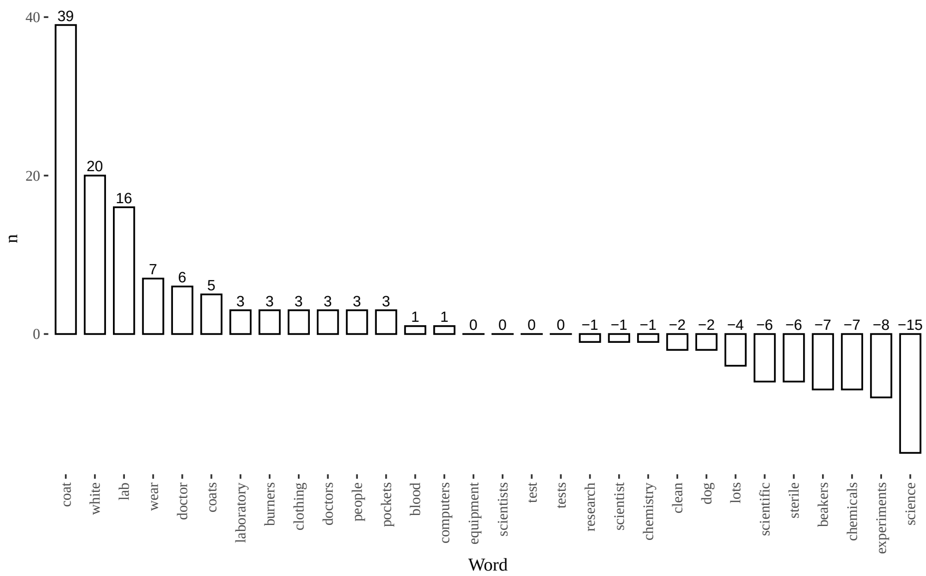



**Figure 19.** The difference in the frequency of words used to describe LAB before and after for Given COAT-LAB, Describe LAB task

Figure 19, shows the difference in frequency of words used before and after. Positive numbers indicate more frequent use *after* adding the word COAT, and negative numbers indicate more frequent use *before* adding COAT. For example, *coat* was used for the description of LAB 39 times more after and *science* and *experiments* were used to describe LAB 15 and 8 times more, respectively, before.

The null hypothesis ($H_0 : p = 0$) that "Subjects show no coat-like change as a result of coprime" and an alternative Hypothesis ($H_1 : p > 0$) that "Subjects show coat-like change as a result of the coprime" were tested. We found a statistically highly significant relationship between copriming and affected results. Thus, $H_0$ is rejected and $H_a$ is supported: "Participant answers show coat-like change as a result of the coprime" or action-reaction Relationships between objects and concepts exist.

3.4.4. Given DOG and COAT, Describe COAT

Fourth, respondents were presented with: Given DOG and COAT, describe COAT.

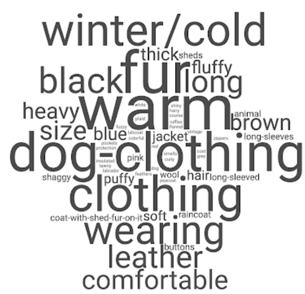
| **Describe COAT.** | **Coprimed with DOG and COAT, Describe COAT.** |
|---|---|
|  |  |





**Table 28.** Comparison of Unprimed COAT to DOG-COAT coprimed COAT

In simple terms, the word cloud Table 28 shows what the data in Table 29 reveals: where subjects described a stereotypical 'winter' 'warm' with 'buttons' for COAT in the baseline measure, they were significantly more likely to describe the COAT as 'fur' and 'dog-clothing,' or 'fluffy' when the copriming took place.

| Coded terms (>1%) | Percent of Total | Frequency |
|---|---|---|
| warm | 20.92% | 64 |
| fur | 15.03% | 46 |
| dog-clothing | 10.46% | 32 |
| clothing | 5.23% | 16 |
| winter/cold | 4.25% | 13 |
| wearing | 3.59% | 11 |
| black | 3.27% | 10 |
| long | 3.27% | 10 |
| leather | 2.61% | 8 |
| size | 2.61% | 8 |
| comfortable | 2.29% | 7 |
| brown | 1.96% | 6 |
| heavy | 1.63% | 5 |
| thick | 1.63% | 5 |
| blue | 1.31% | 4 |
| fluffy | 1.31% | 4 |

**Table 29.** Coded-tags for DOG-COAT Coprimed COAT.

| DOG-like | No | Yes | $X^2$ | $P$ |
|---|---|---|---|---|
| | **Before** | | | |
| | N=237 | N=4 | | |
| | **After** | | | |
| | | | 88.2 | **<.001** |
| No | 144 (60.8%) | 1 (25.0%) | | |
| Yes | 93 (39.2%) | 3 (75.0%) | | |

**Table 30.** Comparison of terms before and after adding the word DOG to COAT

A total of 241 respondents were included in the DOG-COAT study. McNemar's test result was statistically significant, indicating a statistically significant change in responses before and after including the word DOG. Before including DOG, only four respondents used dog-like answers compared to 237 who did not. Of the 237 who did not, 39.2% used dog-like answers after adding the word DOG to the original word COAT (P<.001***).

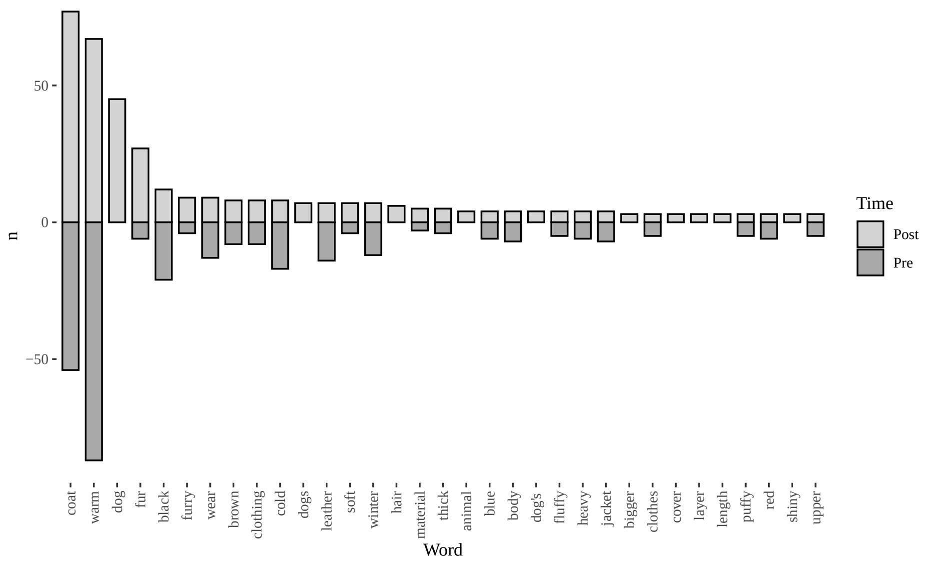



**Figure 20.** Comparison of frequency of words used to describe COAT before and after for Given DOG-COAT, Describe COAT task

Figure 20, compares the frequency of words used before and after. One can see that *dog*, *fur*, and *coat* were more frequent descriptors of COAT after whereas *warm*, *cold*, and *leather* were more frequent before.

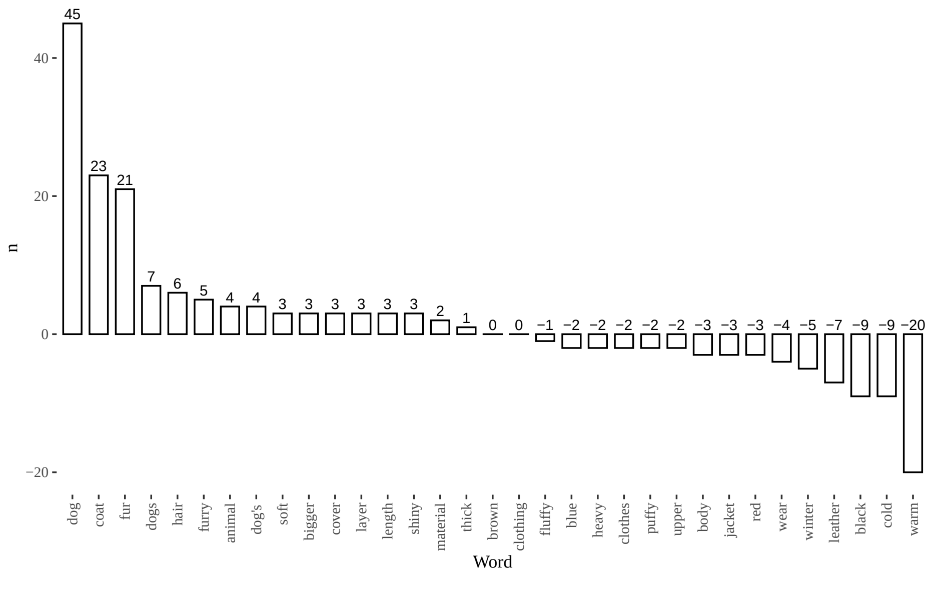



**Figure 21.** The difference in the frequency of words used to describe COAT before and after for Given DOG-COAT, Describe COAT task

Figure 21, shows the difference in frequency of words used before and after. Positive numbers indicate more frequent use *after* adding the word DOG, and negative numbers indicate more frequent use *before* adding DOG. For example, after the relational coprime, the description of COAT was 45 times more likely to include *dog* and 21 times for *fur* whereas before, COAT was described 20 times more as *warm* and 7 times more as *leather*.

The null hypothesis ($H_0 : p = 0$) that "Subjects show no coat-like change as a result of coprime" and an alternative Hypothesis ($H_1 : p > 0$) that "Subjects show coprime-like change as a result of the coprime" were tested across four tasks. We found a statistically highly significant relationship (See Table 31) between copriming and affected results. Thus,

$H_0$ is rejected and $H_a$ is supported: "Subjects answers show coprime-like change as a result of the coprime" or action-reaction Relationships between objects and concepts exist.

| **Coprimes** | *P* |
|---|---|
| Given COAT and LAB, Describe COAT | **<.001** |
| Given DOG and LAB, Describe LAB | **<.001** |
| Given COAT and LAB, Describe LAB | **<.001** |
| Given DOG and COAT, Describe COAT | **<.001** |

**Table 31.** P-values for DOG-LAB-COAT Copriming

### *3.5. The R-Mapping Study Results*

A study (N=34,398) of aggregate data of software users in Plectica[9] systems mapping software, determined what people do (and do not do) when they map a system. 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'). 52% of people in the study made 2,066,654 *identity* distinctions. 48% of people broke down their distinctions into 769,120 parts. 46% of people made 565,999 relationships between things. 25% of people distinguished 87,318 relationships by adding an identity (naming) the relational line. 16% of people took at least one explicit perspective (39,398 perspectives taken). 4% of people distinguished 16,668 perspectives. 2% of people included 3,265 relationships in the view of their perspective as shown in Table 32.

| **Percentages** | **Action Taken** | **Number** |
|---|---|---|
| 48% (N=16,516) | distinguished nothing (i.e., didn't 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 |

**Table 32.** Actions Users Take and Don't Take When Systems Mapping (N=34,398)

This data provides insight into both what people do when mapping using systems thinking, and what they do not do (or could have done but didn't). Table 33 differentiates between what people do (or did) and what they did 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.

[9] 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.

| 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 $R$s) |
| Take only their own Perspective ($P$) [implicitly] | Almost never take explicit perspectives ($P_v^\rho$) |
| | Rarely take multiple perspectives ($n * P_v^\rho$) |
| | Rarely take conceptual perspectives ($C_\rho$) |

**Table 33.** What People Do and Don't Do in Systems Mapping (N=34,398)

Specifically, less than half of people will make Relationships (46% of people related identities 565,999 times). Only 25% of people distinguished their relationships and only 87,318 times; or zoom into them and add parts ($RDS$) or relate the parts of the whole ($p \overset{R}{\Longleftrightarrow} p$). People will look for the *direct* cause ($R$), but rarely think in webs of causality ($S$ of $R$s). Where Relationships are concerned, as a metacognitive skill, two jigs—"Part Parties" and "RDSs"—can be used to dramatically increase cognitive complexity and efficacy in systems thinking.

### *3.6. The R STMI Study Results*

In a study utilizing the Systems Thinking and Metacognition Indicator (STMI) [58] (N=1059), subjects exhibited the well-known Dunning-Kruger Effect [76], where confidence was higher than competence in the action-reaction Relationships (R) skill, as shown in Figure 22. This was the case across all four universals of DSRP Theory (identity-other Distinctions, part-whole Systems, action-reaction Relationships, and point-view Perspectives) but herein we focus on the results for action-reaction Relationships. Subjects' aggregate action-reaction Relationships competency/skill score was 72 whereas their Confidence score was 85—a difference of 13.

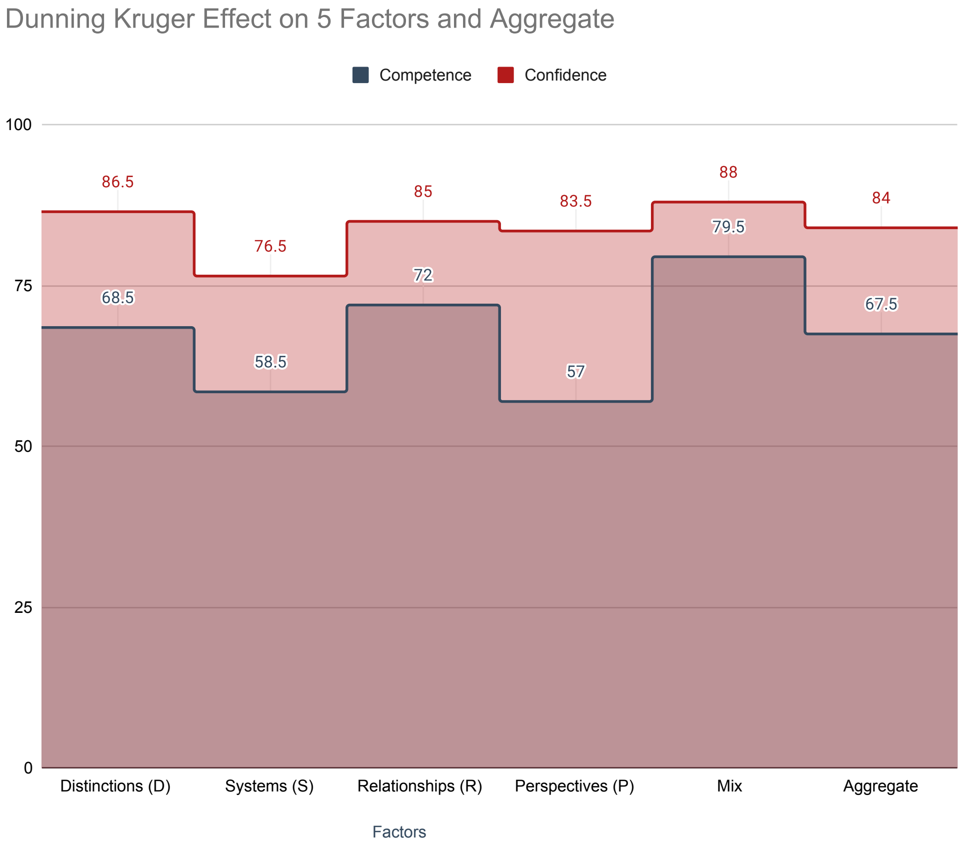



**Figure 22.** Dunning-Kruger Effect in action-reaction Relationships

### *3.7. The R-Fishtank Study Results*

In the Fishtank Study [59], subjects (N=1750) were asked to describe what they saw in a fishtank scene (the static image in Figure 23).

**Figure 23.** Describe what you see...

Responses established the baseline data. Then subjects (N=350) were exposed to a less than one-minute treatment that consisted of reading bulleted text shown in Table 34.

Instructions: Read the following review of the Relationships (action-reaction) Rule. Take your time to read and understand the principles outlined so you can apply them to the next question.

- Relationship rule reminds us to identify and examine the relationships among all the parts of a system. In any system, you want to see not only the nodes - but also the relevant relationships among them to better understand that system.
- action-reaction structure of relationships means that any object or idea is an action or reaction (e.g., Person A can act upon Person B or react to Person B).
- The R rule encourages not only to recognize that a relationship exists but to distinguish that relationship to better understand it (i.e., by naming it, for example the relationship between "mom" and "dad" is "marriage".)
- The R rule encourages not only to recognize that a relationship exists but also to zoom into that relationship to see its constituent parts (e.g., the relationship between a farmer and consumer is a vast supply chain made up of many parts; the synaptic relationship between neurons is made up of electrochemical components).

**Table 34.** Less than 1 Minute Treatment (M=28.11s)

Subjects were then shown the same fish tank image again and asked, "Describe what you see in the image when applying the action-reaction Relationships Rule you just learned (text copied below the image)." This was called the Post-Relationships Treatment (or 'PostR'). The results are shown qualitatively and visually: the differences between the word clouds generated for PreR and PostR shown in Table 35.

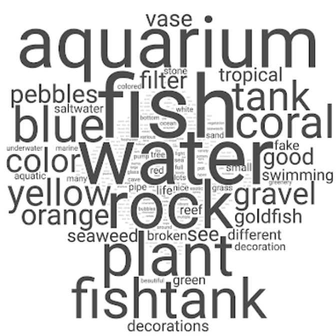
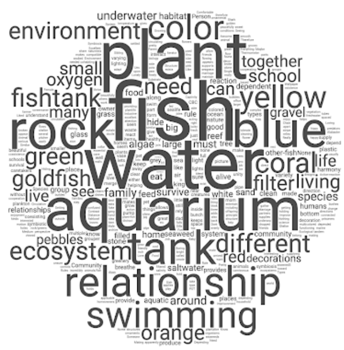
| PreR | PostR |
|---|---|
|  |  |





**Table 35.** Word Clouds of PreR and PostR

It's easy to see that the PostR word cloud is more descriptive and detailed than the PreR word cloud. Larger words mean more occurrences. Smaller words (which appear as grayish halo background) indicate more detail and more words used. We can see certain relational words—such as; relationship, and, to, between —are prevalent in the PostR and nonexistent in PreR. PostR also has more terms (more tiny words producing a grey halo). We see these same patterns in the quantitative data. On every dimension,the PostR exceeded the PreR data (Table 36), indicating that PostR responses increased in their quantity and were more interrelational.

| | PreR | PostR | Difference |
|---|---|---|---|
| No. of characters (including spaces) | 18443 | 21965 | +16.03% |
| No. of characters (without spaces) | 11271 | 13132 | +14.17% |
| No. of words (including repeated words) | 2248 | 2814 | +20.11% |
| No. of syllables (including repeated words) | 3532 | 2814 | +20.11% |
| No. Unique words | 279 | 466 | +40.13% |
| No. of characters (no spaces) for Unique Words | 1578 | 2684 | +41.21% |
| No. of syllables for Unique Words | 537 | 926 | +42.01% |
| Total Unique Word Occurrence | 2138 | 2553 | +16.26% |

**Table 36.** PreR and PostR Aggregate Response Data

Relational words made up significantly more of the PostR total than in the PreR condition. Connector words like: and (78), in (67), of (61), to (61), relationship (41), are (32), for (24), with (20), different (16), between (16) (See Table 38). In fact, relational words were 2.96 times more common, -ing words were 1.40 times more common, and verbs were 6.38 times more common in PostR than PreR (See Table 37).

| **Relationship words** | | **PreR** | | **PostR** | **Difference** |
|---|---|---|---|---|---|
| Word Occurrences | | 2,138 | | 2,553 | 1.19x |
| Relational words | 13 | 0.61% | 46 | 1.80% | 2.96x |
| *-ing* ending words | 15 | 0.70% | 25 | 0.98% | 1.40x |
| Verbs | 53 | 2.48% | 404 | 15.82% | 6.38x |

**Table 37.** PreR and PostR Relational Words Analysis of Unique Words

Unique words and their occurrences were cleaned from the total words and the Top 40 words from PreR and PostR are shown in Table 38.

| | PreR (Total 2138) | | | PostR (Total 2553) | | |
|---|---|---|---|---|---|---|
| Rank | Word | Occurs | % | Word | Occurs | % |
| 1 | fish | 440 | 19.78% | fish | 404 | 14.36% |
| 2 | water | 151 | 6.79% | water | 154 | 5.47% |
| 3 | aquarium | 127 | 5.71% | and | 78 | 2.77% |
| 4 | rock | 116 | 5.21% | in | 67 | 2.38% |
| 5 | plant | 99 | 4.45% | plant | 62 | 2.38% |
| 6 | blue | 65 | 2.92% | of | 61 | 2.17% |
| 7 | fishtank | 64 | 2.88% | to | 61 | 2.17% |
| 8 | coral | 55 | 2.47% | aquarium | 56 | 1.99% |
| 9 | color | 43 | 1.93% | rock | 49 | 1.74% |
| 10 | tank | 41 | 1.80% | blue | 41 | 1.46% |
| 11 | yellow | 40 | 1.80% | relationship | 41 | 1.46% |
| 12 | gravel | 35 | 1.57% | tank | 40 | 1.42% |
| 13 | orange | 33 | 1.48% | are | 32 | 1.14% |
| 14 | of | 31 | 1.39% | is | 30 | 1.07% |
| 15 | in | 24 | 1.08% | swimming | 28 | 1.00% |
| 16 | and | 20 | 0.90% | color | 26 | 0.92% |
| 17 | filter | 20 | 0.90% | for | 24 | 0.85% |
| 18 | pebbles | 20 | 0.90% | yellow | 23 | 0.82% |
| 19 | vase | 19 | 0.85% | coral | 21 | 0.75% |
| 20 | see | 17 | 0.76% | with | 20 | 0.71% |
| 21 | tropical | 17 | 0.76% | good | 19 | 0.68% |
| 22 | goldfish | 16 | 0.72% | other | 19 | 0.68% |
| 23 | seaweed | 16 | 0.72% | ecosystem | 17 | 0.60% |
| 24 | with | 16 | 0.72% | different | 16 | 0.57% |
| 25 | decorations | 13 | 0.58% | environment | 16 | 0.57% |
| 26 | swimming | 13 | 0.58% | fishtank | 16 | 0.57% |
| 27 | different | 12 | 0.54% | that | 16 | 0.57% |
| 28 | reef | 12 | 0.54% | between | 15 | 0.53% |
| 29 | broken | 11 | 0.49% | green | 15 | 0.53% |
| 30 | green | 11 | 0.49% | need | 15 | 0.53% |
| 31 | fake | 10 | 0.45% | be | 14 | 0.50% |
| 32 | life | 10 | 0.45% | filter | 14 | 0.50% |
| 33 | saltwater | 10 | 0.45% | goldfish | 14 | 0.50% |
| 34 | decoration | 9 | 0.40% | on | 14 | 0.50% |
| 35 | is | 9 | 0.40% | each | 13 | 0.46% |
| 36 | small | 9 | 0.40% | orange | 13 | 0.46% |
| 37 | aquatic | 8 | 0.36% | living | 12 | 0.43% |
| 38 | are | 8 | 0.36% | can | 11 | 0.39% |
| 39 | pipe | 8 | 0.36% | oxygen | 11 | 0.39% |
| 40 | red | 8 | 0.36% | school | 11 | 0.39% |

**Table 38.** PreR and PostR Top 40 Terms Used

Data (N=382) was summarized using median [IQR]. Statistical analysis was performed using Wilcoxon-Signed rank test. Results in Table 39 show that the distribution of concepts was significantly different before and after treatment (P = <.001*** using Wilcoxon signed-rank test) with a lower average number of concepts observed after treatment. The distribution of the number of words used after treatment (M = 4, IQR 2 – 9) was significantly different from that observed before treatment (M=4, IQR 3–7, P=0.003*). The distribution of the number of characters used after treatment (M=23, IQR 10–51) was significantly higher than the median number of words used before treatment (M=23, IQR 13–38, P=0.015*).

| | Pre | Post | P.overall |
|---|---|---|---|
| **No. concepts** | 3.00 [2.00;5.00] | 2.00 [1.00;3.00] | **<.001** |
| **No. words** | 4.00 [3.00;7.00] | 4.00 [2.00;9.00] | **0.003** |
| **No. characters** | 23.0 [13.0;38.0] | 23.0 [10.2;50.8] | **0.015** |

**Table 39.** R Comparison of raw counts, words, and characters before and after treatment

In every aspect, a less than one-minute treatment of R-rule led respondents (*with high statistical significance*) to increase the complexity of what they saw in a scene and how they described it. Figure 24 shows two [of several] of the dimensions where subjects increased the cognitive complexity of responses with highly statistically significant results. Lewis and Frank [77] showed that the length of words reflects their conceptual complexity.

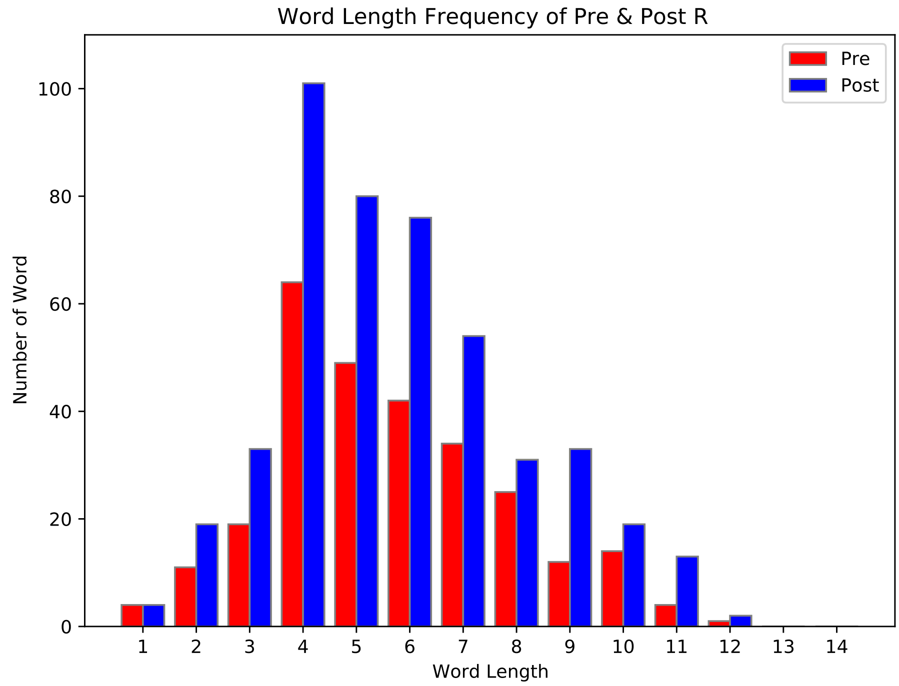



**Figure 24.** Increased Cognitive Complexity of Response After < 1 Minute Treatment of R-Rule

## 4. Discussion of Findings

In the *Affective Squares Study*, *What Makes a Square*, *What Makes a Circle*, and *Dog-Lab-Coat studies*, we see that the co-affecting effects of action-reaction Relationships (R) exist, and even if unconscious to the subject, occurs universally. We see too, that the act of distinguishing identities and others (D-rule), even in the most basic ideas and objects such as *medium square*, is dependent on R-rule and vice versa. We see that action-reaction Relationships exist in both mind and nature, as they can be easily *educed*. All of these studies indicate that action-reaction Relationships (R), while universal, is also *dependent* on the other universals predicted by DSRP Theory (identity-other Distinctions (D), part-whole Systems (S) and point-view Perspectives (P)). Finally, the *R-STMI*, *R-Mapping*, and *R-Fishtank* studies illustrate the efficacy of R-rule as a metacognitive skill. Taken together as an ecology, these studies show the existence, universality, efficacy, and parallelism of action-reaction Relationships (R) high statistical significance.

### *4.1. The Affective Squares Study Findings*

Copriming effects, the result of relationships, exist. People make relationships without being asked to. Table 40 shows that the way people distinguish things is based on not only the essence of the thing itself but on how the thing *relates* to other things in its context. An overwhelming majority of the time (96.78%, 98.51%, and 99.26%) subjects dragged each label to the corresponding square relative to the other squares around it. Thus, meaning making is *relational* in nature and objects or ideas have copriming effects (action-reaction) on each other. This shows that *distinguishing* any idea or object requires *relationships*, often unconsciously, between and among other ideas and objects.

| |  |  |  |
|---|---|---|---|
| Small Square | **96.78%** | 0.74% | 0.25% |
| Medium Square | 2.72% | **98.51%** | 0.25% |
| Large Square | 0.25% | 0.50% | **99.26%** |

**Table 40.** Relational Distinction Making of Objects (N=403)

### *4.2. The What Makes a Square? Study Findings*

The *What Makes a Square?* Study shows that the identity of something (in this case a square) is determined not only by what that something is (square) but also by what it is not (small, medium, large) in *relation* to other things (in this case, other squares). It shows that when two items exist in the same "domain of discourse" there is a copriming effect where one object acts upon and reacts to the other and vice versa. The results of this study also show the relational nature of distinction making, and demonstrates that making relationships is empirical. ‘A’ is distinguished not merely based on what it is (a square) but also in relation to the other objects it is with (larger or smaller squares).

The dynamism of relational copriming was tested to see if the same identity changed when the other objects around it (its context) changed. In other words, in Table 41 the identity of square-A changes when its position or relation to other squares changes. In the baseline condition the majority of subjects, when asked to identify square-A, chose ’square’ (55.17%); other answer choices were equally plausible given that the square had no context in terms of size. In the second task, subjects were asked again to identify square-A and 75.36% selected Large Square. In the third task, square A was larger than B but smaller than C and 81.77% chose Medium Square. The findings for the *What Makes a Square Study* is that *squares are relative*. That is, whenever something appears or exists in the same domain as something else (which barring a vacuum is always, and even a vacuum is something other than the thing) those items, objects, ideas are copriming. They are *relative*. Square A is neither inherently large nor inherently small nor inherently medium. It is small relative to larger squares, and large relative to smaller squares. The same could be said for *any* attributes. A square is relatively more squary than a circle which is relatively more circly than a square. Colors are brighter or darker relative to the other colors they are with. Our roles change, and even our personality and demeanor, relative to whom we are around. A newborn son brings a father into existence at the same time that the father makes the son exist. These dynamical changes are *relative*.

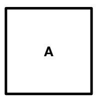
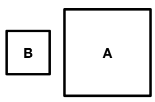
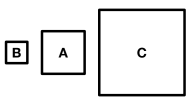
| **Identify A:** | **Answer Choices** | | | |
|---|---|---|---|---|
| | **Square** | **Large Square** | **Medium Square** | **Small Square** |
|   | **55.17%** | 26.35% | 14.77% | 3.69% |
| | *Baseline* | | | |
|   | 6.89% | **75.36%** | 8.62% | 9.11% |
|   | 3.44% | 10.34% | **81.77%** | 4.43% |

**Table 41.** Relative Square Data (N=406)

This study shows that distinguishing the same object as given in three independent tasks, shows that for each task a new distinction was made, independent of the prior task.

This independence was caused by the [often unconscious] relationship between objects. Normally, priming effects would occur as a result of previous tasks (cross-task), but in this case we see that the priming occurs *relationally* within each task. In other words, regardless of the prior task, subjects made new distinctions based on Object A's relationships to the other objects offered in the task. Importantly, this shows that a relationship (even a subconscious one) acts as a perspective and is necessary for distinction making.

### 4.3. The What Makes a Circle? Study Findings

The *What Makes a Circle?* study further illustrates the relative, or relational, nature of distinction making that was shown in the *What Makes a Square?* study. In other words, in both studies, a square/circle is distinguished not merely based on what it is (a square/circle) but also relative to the other objects it is with (larger or smaller squares/circles and left, middle, or right circles).

Of note, while it is clear that subjects distinguished each circle relationally, it also appears that in the case of the middle circle 29.92% of subjects labelled it as 'left' indicating that they switched perspective midstream and considered the middle circle to be to the left of the right circle (only 8.66% did so in reverse for right of left circle). In other words, each response is based on a relationship to the other circles, and even when the physical position is not as clear as in the center circle, the responses given were still based on a relationship between the center circle and either the circle to it's right or left side.

We agonized over the apparent anomaly in the data (see Table 13). Why would such a large number of respondents distinguish Circle 3 as being the "Center Circle?" All of the other data made sense and supported the Alternative Hypotheses with high statistical significance, even with this anomaly. But it was still a mystery to us. We kept asking, "*How could 37% of respondent answers distinguish the far-right, large circle as being center?*" We checked and quadruple checked the data. Then we looked at the actual screen that respondents were looking at when they did the task shown in Figure 25. Circle 3 was actually positioned in the *center* of the *screen*!

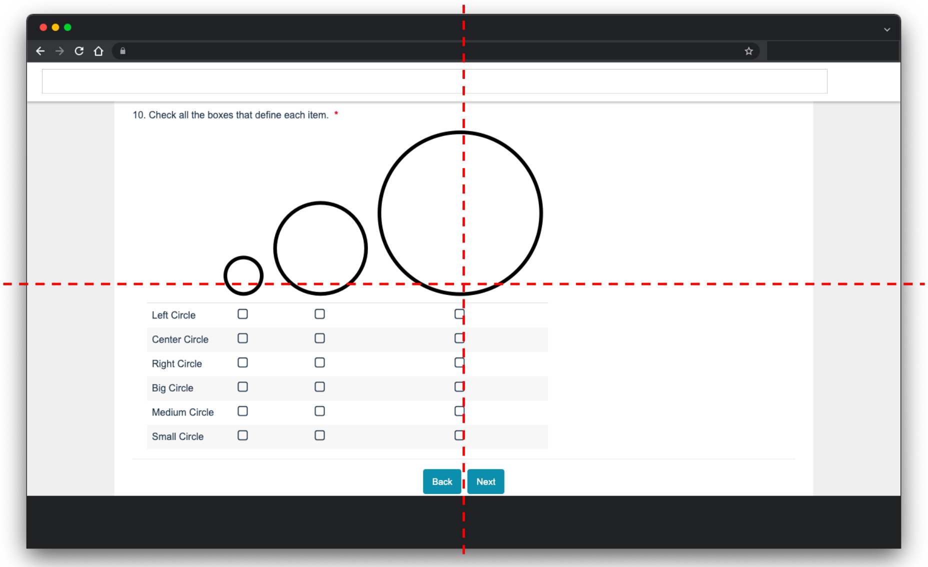



**Figure 25.** Circle 3 Center?

In fact, as Table 42 shows subjects overwhelmingly did what was expected by the alternative hypothesis but they also did some less expected things (shown as implicit expected (↔) and unexpected (↔) Relationships). One can see that in each answer chosen, the subject altered the relationships they were considering and not considering. But they also redrew the boundaries of the Systems (shown as []) leaving some circles in and out (Distinctions) out of consideration (shown in (gray). In addition, with each defining answer, subjects recast their Perspectives (shown as $[\,]_s$=by size; $[\,]_p$= by position). What this means is that even in a simple task such as define 3 circles by six descriptors, at each decision point subjects are dynamically recasting the D,S, R, and P structures to make meaning and arrive at conclusions.

There is a perspective (represented by brackets [ ]) which is provided by the researchers of the initial question. This perspective is comprised of the three circles such that [① ② ③ ]. Subjects therefore decide whether Circle 2 is Center or Medium based on relationships between the circles within this context [① ↔ ②↔ ③ ]. Remarkably, what we see is that, while subjects use this perspective the majority of the time, they also alter the perspective to yield different but equally plausible responses. For example, Circle 2 is left of Circle 3 but in order for this to be the case, Circle 1 must be ignored, or left out of the perspective such that ① [ ②↔ ③ ] (note also the part-whole systematization). In this case, Circle 2 is "to the left" of Circle 3. In Table 42 we see the expected (Alternative Hypotheses) relationships denoted by ↔, but we also see a significant number of reframed *perspectival* and *relational distinctions* denoted by [↔]. While this study intended to show the influence of co-relationships on distinction making, subjects showed us the natural influence of perspective on distinction making yielding unexpected but completely rational responses about the relationships among the circles. Indeed, as Figure 25 shows, subjects not only created new perspective inside the one given to them by researchers, but also created new perspectives well-outside of the bounds of the research. This illustrates the fractal nature of perspectives, relationships, systems, and distinctions and DSRP.

| | 1 | 2 | 3 |
|---|---|---|---|
| Left | [∘ ↔ ○ ↔ ◯]$_p$ 65% | ∘ [○ ↔ ◯]$_p$ 23% | ... |
| Center | ... | [∘ ↔ ○ ↔ ◯]$_p$ 55% | ∘ ○ [○ ↔ ◯]$_p$ 38% |
| Right | ... | [∘ ↔ ○]$_p$ ◯ 11% | [∘ ↔ ○ ↔ ◯]$_p$ 80% |
| Big | ... | [∘ ↔ ○]$_s$ ◯ 10% | [∘ ↔ ○ ↔ ◯]$_s$ 81% |
| Medium | ... | [∘ ↔ ○ ↔ ◯]$_s$ 86% | ... |
| Small | [∘ ↔ ○ ↔ ◯]$_s$ 85% | ∘ [○ ↔ ◯]$_s$ 7% | ... |

**Table 42.** Implicit expected (↔) and unexpected (↔) Relationships, Systems ([]), Perspectives ($[\,]_s$=by size; $[\,]_p$= by position), and Distinctions (gray) Used in Defining a Circle

### 4.4. The Copriming Dog Lab Coat Study Findings

This results of this study clearly show that (1) action-reaction Relationships (R) exists and also that any two words that appear in the same domain will have copriming effects as a result of the R rule. Indeed, it is because of the R rule that priming effects work as a research technique. It is also why savvy marketing campaigns informed by neuromarketing are able to repeatedly place two or more items in proximity (e.g., Coke/Life, Happy/Meal, Osama/Obama) and manipulate consumers for votes, money, or attention.

The highly statistically significant results of this study, combined with results from the other studies, show that just like fireflies and other organisms in nature can be mutually reinforcing (excitatory or inhibitory) coupled oscillators that influence the emergent properties of system-wide behavior [78,79] concepts too, can be coupled oscillators. This has important implications and applications for DSRP Theory, because it confirms several of the hypotheses, implications, and predictions that DSRP Theory makes.

First, action-reaction Relationships (R) are central to the co-implication rule between the two Elements of each of the 4 Patterns (identity-other Distinctions (D), part-whole Systems (S), action-reaction Relationships (R), and point-view Perspectives (P)).

Second, action-reaction Relationships (R) are instrumental to the simultaneity dynamics in structural predictions. The massively relational nature of fireflies and other organisms in complex adaptive systems mimic those of concepts (DOG, LAB, COAT) when they exist in proximity to each other. They form an $n(n-1)$ copriming network where $n$ number of nodes in the network are copriming with the *other* $n-1$ nodes in the network. Likewise all 8 Elements of DSRP act simultaneously as the other 7 and—acting as coupled oscillators—"vibrate" each other into existence. *Vibrate* may seem like a strange word to use here, but it captures the essence of these *affecting-effecting* action-reaction Relationships (See Figure 26). Indeed, *any* pair or collection of things, in both mind and nature (e.g., words, concepts, organisms, objects, etc.) can exhibit these kind of action-reaction Relationships.

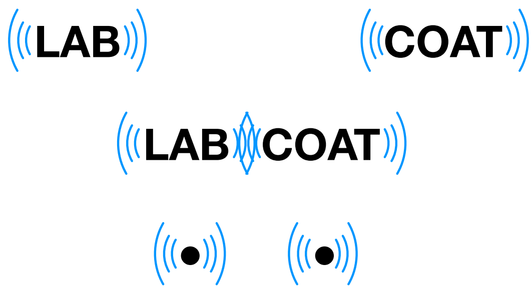



**Figure 26.** R-rule and Domain Proximity

In other words, action-reaction relationships are as prevalent in DSRP Theory as they are among any things in reality (words, organizations, and people).

Third, these copriming effects (as a simple rule between any agents in any system) means that any parts of a whole, by their proximity in sharing the same containment, have a high probability of interrelationship, thus the structural prediction based on these properties is highly probabilistic.

Fourth, the findings of these studies clarify important disagreements about *order of operations* between any two items; as it shows that it is so often the case that '*both occur in unison*.' Thus, in DSRP Theory, in the same way that a man becomes a father at the very moment when a boy becomes a son, it is also the case that: a Perspective forms as the oscillation of point-view; a System forms on the coupling of part and whole; an Distinction is born as twin-births of identity and other.

Fifth, it means that even a relatively innocuous addition to a system of parts can have a transforming effect on the whole. This is precisely because of the action-reaction Relationships that occur when parts are in proximity.

*4.5. The R-Mapping Study Findings*

The prior studies get at the *existence* of action-reaction Relationships. The *Fishtank*, *STMI*, and ***R Mapping*** data shows that action-reaction Relationships not only exist but can be utilized as a metacognitive skill with highly statistically significant effect and can be measured in terms of competence and confidence.

Table 32 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 aligns with case-based and anecdotal experience that 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 32 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 33 summarizes this data and also what we can learn by providing a list of things we can continue to do and things we can try to do more of. This list is quite literally 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.

*4.6. The R-STMI Study Findings*

Specifically, in both the *Fishtank Study* and the *R STMI Study*[10], we see the theoretical universal of part-whole Systems can also be utilized as a metacognitive skill that can be measured in both competence/skill and confidence. The Dunning-Kruger effect that appears in our sample illustrates that we should be careful not to overestimate our competency in the action-reaction Relationships skill.

*4.7. The R-Fishtank Study Findings*

The *R Fishtank Study* shows with high statistical significance that a short (less than 1 minute) intervention based on the basic concepts of action-reaction Relationships can have a positive effect on the complexity of cognition. People see not only quantitatively more, but qualitatively deeper as well. Given the limited exposure to treatment (on average, a 28.11 second read of bullets of text), these findings indicate a statistically significant increase in the degree to which people made more detailed relationships. With a more substantive treatment (such as a short course) one can imagine the effects may be transformative.

*4.8. Summary of Findings on Existence, Universality, Efficacy, and Parallelism*

In these 7 studies, we see that the *action* and *reaction* elements of the *Relationships* pattern are *inextricably linked*, *co-implying* and *interchangeable*.

$$\begin{aligned}
&\mathbb{D} : \exists AB \\
&\exists A_a \xRightarrow{\text{implies}} \exists B_r \\
&\exists B_r \xRightarrow{\text{implies}} \exists A_a \\
&\exists A_a \xLeftrightarrow{\text{co-implies}} \exists B_r
\end{aligned} \tag{4.1}$$

In Equation 4.1 we see that if in the *domain of discourse* ($\mathbb{D}$) there *exists* ($\exists$) any content information $A$ and $B$, then $A$ will have an $A$-like *action* ($A_a$) on $B$ and vice versa. And, $B$ will have an $B$-like *reaction* ($B_r$) on $A$ and vice versa. Thus, if an action $A_a$ ($\exists$), then it *implies* ($\Rightarrow$) that a reaction $B_r$ exists and vice versa. Thus, action and reaction, as structural patterns of cognition are *co-implying*.

[10] Both the Fishtank [? ] and the STMI Study focused on more than just the existence of action-reaction Relationships. See [58]

Thus, in Equation 4.2, we see that the *action-reaction* elements of *Relationships* are *universal* to all forms of links, causes, connections, edges, etc. And, these universal elements are *interchangeable* such that any *action* can also function as *reaction* and vice versa:

$$
\begin{aligned}
& R = a \overset{\text{co-implies}}{\Longleftrightarrow} r \\
& f : a \rightarrow r \\
& f : r \rightarrow a
\end{aligned} \tag{4.2}
$$

In other research studies, the identity and other variables of Distinctions (D) [**?** ], the part and whole variables of Systems (S) [**?** ], and the point and view variables of Perspectives (P) [**?** ], were all shown to be action-reaction Relationships (R), for example, that the elements of D, S and P are all copriming and co-implying. Like the studies presented herein for action-reaction Relationships (R), an ecology of studies was undertaken to test the existence and efficacy of, respectively, D, S and P rules. These studies show that R is a factor in the formation of identity-other Distinctions, part-whole Systems, and point-view Perspectives.

These 7 studies (along with the other studies mentioned) provide an "ecology" of findings about action-reaction Relationships. Each study adds a brick to the wall of our understanding of action-reaction Relationships (a.k.a., links, causes, connections, edges, etc.) and answers important questions about: (1) how and why they form, (2) their internal and external dynamics, (3) the role they play in individual and social cognition, (4) the role they play in metacognition, and (5) the effects of metacognitive awareness of action-reaction Relationships on cognitive complexity.

The *What Makes a Square?* and *What Makes a Circle?* studies illustrate the relative, or relational, nature of distinction making: that a square is distinguished not merely based on what it is (a square) but also relative to the other objects it is with (larger or smaller squares). Combined with previous Distinction studies, these relational, identity-other studies elucidate how the multiplicity of names (distinctions) which any given item can have, creates an 'other-like' network of relations that, while often unconscious, is essential to the way that associative cognition operates. The *Affective Squares* study buttresses these findings and extends them to show that meaning making is relational in nature and objects or ideas have universal relational copriming effects (action-reaction) on each other. The Copriming Dog Lab Coat study explicates (to high statistical significance) these relational copriming (action-reaction) effects between concepts and objects and shows the universality of Relationships to cognition.

From the results of these 7 studies of action-reaction Relationship structure detailed above, we can conclude that action-reaction Relationships (R) 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.;
   (b) in *nature* (i.e., physical/material, observable systems, matter, scientific findings across the disciplines, etc.);
   (c) because both mind and nature are material, distinct material identities and part-whole Systems (e.g., RDSs); and
   (d) the basis for massively parallel action-reaction-effects in networks in both mind and nature (i.e., action-reaction relationships (R) form an $n(n-1)$ copriming network where $n$ number of nodes in the network are copriming with the *other* $n-1$ nodes in the network).
2. Made up of elements (action, reaction) that are:
   (a) *co-implying* (i.e., if one exists, the other exists; called the co-implication rule);

   (b) related by a special[11] relationship: effect/affect; and
   (c) act simultaneously as, and are therefore interchangeable with, the elements of Distinctions (identity, other), Systems (part, whole) and Perspectives (point, view). This is called the simultaneity rule.
3. Mutually-dependent on identity-other Distinctions (D), part-whole Systems (S), point-view Perspectives (P) such that D, S, R, and P are both 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.

With these findings in mind we can return to our table of research questions (3) 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 action-reaction Relationships (R) and with high statistical significance point to the conclusions and summaries in Table 43.

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

| Conclusions | Summary |
| --- | --- |
| Globally and universally, action-reaction relationships exist. | $R_r^a$ 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. Distinctions are relational. People define things relative to other things. | Meaning is literally, *relative*. |
| Relationships are made at the individual and collective level. | $R_r^a$ is universal. |
| At the individual level, people make a diversity of relationships, collectively, they see things similarly. | In a pool of difference, we relate things similarly. |
| Whenever two things share the same physical or conceptual space they have a potential for a relationship. This has big implications for bias, teaching & learning, marketing manipulation, etc. | Metacognition of R matters. |
| In the process of making Distinctions, people rely on relationships. The way they make relationships changes the Distinction they make. The relationality of ideas and objects can completely transform the ideas and objects. | Relationships are *transformative*. |
| Every relationship has an *action* and *reaction* variable where idea or object A has an A-like action on B; and vice versa. | I am a relationship. Hear me Rar. ($R_r^a$) |
| R-rule is dependent on D, S and P rules, and D, S and P rules are dependent on R-rule. | DSRP is massively parallel and fractal. |
| We know what people do and don't do with Relationships that can help us improve thinking. Namely: Rarely distinguish relationships; rarely challenge existing relationships; rarely systematize relationships; rarely think in webs of causality. | Awareness of R-rule improves thinking. |
| People have greater confidence than competence in seeing and making Relationships. | We are overconfident with $R_r^a$ |
| A relatively short treatment in R-rule can dramatically affect cognitive ability and complexity. | "R-rule" makes you smarter. |

**Table 43.** Summary Table of Conclusions

**Author Contributions:** Authors contributed equally in methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision, project administration, funding acquisition. Development of DSRP Theory, D.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**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 on request from the corresponding author. The data are not publicly available due to privacy, human subjects, and ethical considerations.

**Acknowledgments:** None.

**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 modelling |
| RDS | Relate-Distinguish-Systematize Jig |

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