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The "Fish Tank" Experiments: Metacognitive Awareness of Distinctions, Systems, Relationships, and Perspectives (DSRP) Significantly Increases Cognitive Complexity

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Abstract: In the field of systems thinking, there are far too many opinioned frameworks and far too few empirical studies. This could be described as a "gap" in the research but it is more like a dearth in the research. More theory and empirical validation of theory are needed if the field and the phenomenon of systems thinking holds promise and not just popularity. This validation comes in the form of both basic (existential) and applied (efficacy) research studies. This article presents efficacy data for a set of empirical studies of DSRP Theory. According to Cabrera, Cabrera, and Midgley, DSRP Theory has equal or more empirical evidence supporting it than any existing systems theories (including frameworks, which are not theories). Four separate studies show highly statistically relevant findings for the effect of a short (less than one minute) treatment of D, S, R, and P. Subjects' cognitive complexity and the systemic nature of their thinking increased in all four studies. These findings indicate that even a short treatment in DSRP is effective in increasing systems thinking skills. Based on these results, a longer, more in-depth treatment—such as a one hour or semester long training, such is the norm—would therefore likely garner transformative results and efficacy.

Keywords: metacognition; universals; cognitive complexity; systems thinking; DSRP Theory; material complexity; systems science

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1. Introduction

There is currently a dearth[1] of empirical research into what systems thinking is and how it can be improved. As a hypothetical example, a team of observers trained only in the current literature on systems thinking and shown one hundred instances of thinking would find it futile to determine empirically how many of those one hundred instances were instantiations of systems thinking. Nor would they be able to measure to what degree the instances were or were not systems thinking. In other words, we use the term systems thinking as if we know what it is and can reasonably measure it, when we cannot. Even more, many of the claims about systems thinking or definitions for it are not empirical to begin with, in that they have not or cannot be validated.

Cabrera [1] expanded on systems thinking theoretically by proposing [1–6] DSRP Theory, which details four empirical patterns of both mind and nature: identity–other Distinctions (D). part–whole Systems (S), action–reaction Relationships (R), and point–view Perspectives (P). Each pattern is composed of two elements. In its simplest form, DSRP Theory states:

$$\text{“the ways } \overbrace{\text{information}}^{\text{that which is Organized}} \text{ is/is not } \overbrace{\text{bounded,}}^{\text{Distinctions}} \ \overbrace{\text{arranged,}}^{\text{Systems}}$$

$$\text{and } \overbrace{\text{interconnected}}^{\text{Relationships}} \text{ from } \overbrace{\text{frames of reference}}^{\text{Perspectives}} \text{ determines}$$

$$\overbrace{\text{what actually exists}}^{\text{Material Complexity (Nature)}} \text{ and } \overbrace{\text{what we think exists.”}}^{\text{Cognitive Complexity (Mind)}}$$

But DSRP Theory entails more than is relayed by this simplified statement [1,7–10]. Cabrera, Cabrera, and Midgley [2], discussing DSRP Theory has launched a fourth wave in the field of systems thinking, pointed out that:

> Since Cabrera's first writings, we now have the benefit of over 20 years of hindsight on the possible start of a fourth wave (which is as long as the gap between the first and second waves, and twice as long as the gap between the second and third waves). During those years, we have seen considerable testing of Cabrera's DSRP Theory, including: (1) a burgeoning amount of empirical evidence (at least as much as has been offered in the previous waves); (2) substantial private sector funding to develop tools for systems thinking; (3) substantial public funding for research; (4) a substantial peer review and publication history, sizeable citation histories, including several special issues dedicated to DSRP; (5) considerable public exposure and critique; (6) public adoption; (7) high attendance annual conferences; institutional recognition and support; and (9) as yet, few competitor theories (at least, none that have been explicated and communicated to the same degree).

Cabrera details DSRP Theory in a primer [11] and also elaborates on the the literature and evidence base for DSRP Theory ([1,3,11–18]) as well as, specifically, the literature on: identity-other Distinction making (D) [5,19–89]; part–whole Systems (S) [1,5,21,48,49,57,59–105] action-reaction Relationships (R) [1,5,21,57,59–89,105–120]; and, point-view Perspectives (P) [5,12,57,59–89,121–153].

Cabrera's 2021 review of research [12] builds upon two previous literature reviews [1,6], 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. Figure 1 shows the methodological distribution of this research and Figure 2 shows the distribution of these studies across DSRP pattern.

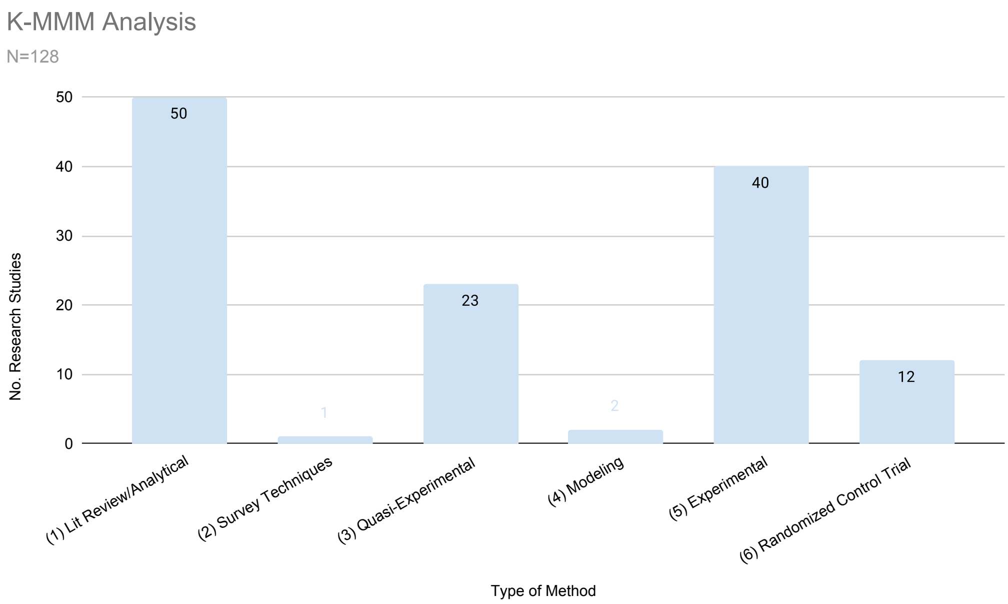


Figure 1. Knowledge-Method Matching Matrix (KMMM) analysis of empirical findings in DSRP across the disciplines.

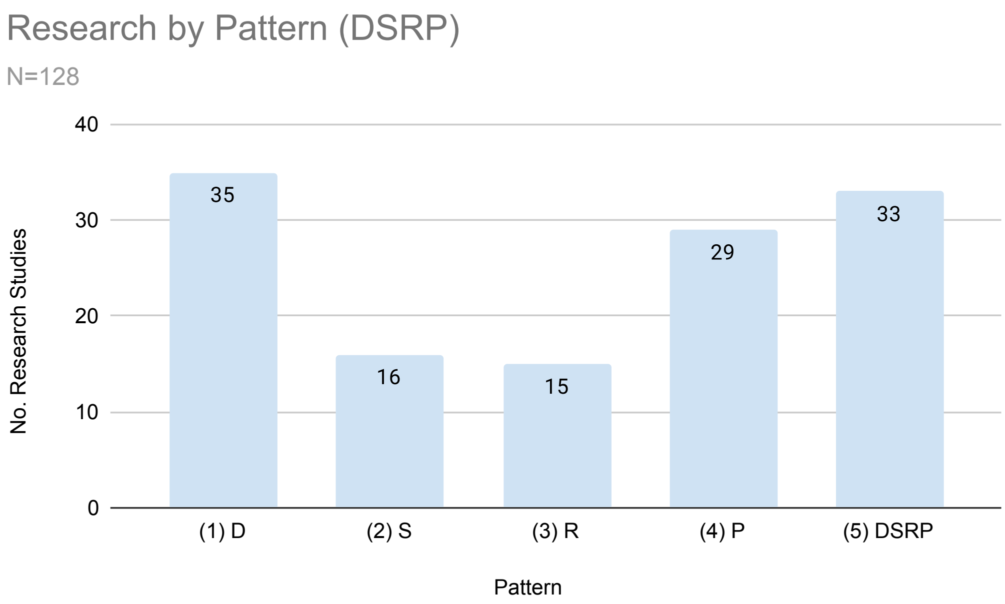


Figure 2. K-MMM analysis of empirical studies by DSRP pattern.

The Importance of Metacognition in Systems Thinking

Cabrera et al. (2021) [154] writes, "An important aspect of systems thinking is the act of metacognition. The process of deliberately structuring one's thoughts using the four building blocks of cognition (D, S, R and P) requires awareness of, or thinking about, one's own thinking, or metacognition" (p. 11, [154]). Systems thinking is synonymous with cognitive complexity. Thus, DSRP Theory further stipulates that awareness of the D, S, R, and P structures (i.e., "metacognition of DSRP") can increase one's effectiveness in thinking about systems, modeling systems, or in increasing cognitive fluidity, complexity and robustness. Table 1 shows the research matrix upon which our hypotheses, null hypotheses, research design, and findings are based.

Table 1. Four dimensions of research program.

	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	

Thus, the "fish tank studies" described herein is part of a research program that empirically tests the *efficacy* of DSRP in understanding Mind/Nature. Thus, this research addresses the questions: Is DSRP effective? Does metacognition of DSRP increase effectiveness in navigating cognitive complexity in order to understand system (ontological) complexity? This gets at the critically important 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[2] (Figure 3).

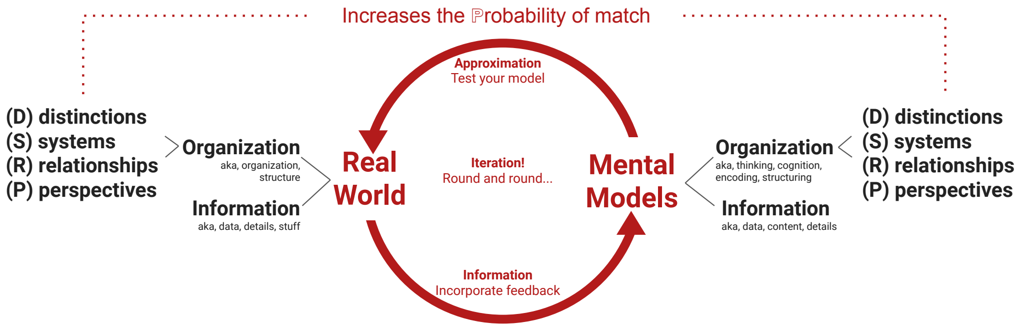


Figure 3. The ST/DSRP loop [11].

Metacognition is therefore intimately tied to systems thinking because it requires—at the very least—a recognition of mental models as existent. Beyond that, metacognition is required to build awareness and purposeful use of cognitive patterns that increase systemic thinking or cognitive complexity, rather than those structures that might cause to lessen it. Generally, research has shown that metacognitive awareness of a skill promotes and improves overall performance. As Stephen Fleming writes, "Insights into our own thoughts, or metacognition, is key to high achievement in all domains" [155]. This includes metacognitive awareness of the universal patterns of mind and nature: Distinctions, Systems, Relationships, and Perspectives (DSRP) [1–6]. Empirical studies have shown that the DSRP patterns exist universally in the mind *and* in nature [3]. In this study, we aim to demonstrate that through isolating the Distinction, System, Relationship, and Perspective patterns using a short (<1 min) treatment, a significant effect can be made on each participant.

Metacognition, or the concept of "thinking about one's thinking", is not a new concept. Many credit John Flavell with the first use of the term metacognition in 1979 [156]. Flavell defined metacognition as, "metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them" (p. 232, [157]). His research focused on whether children were aware of their thinking and cognitive processes.

While Flavell coined the term, he was not the first to explore the idea of thinking about your thinking. Piaget [158] did his work in the early years of cognitive development research and wrote about "knowing the knowing and thinking the thinking" in *The Psychology of Intelligence* [158]. Aturk and Sahin [159] point out that the origin of thinking about your thinking could have happened much earlier.

> "According to Georghiades (2004), being aware of one's cognition was already been mentioned by Plato. Likewise, Aristotle pointed out that mind used a different power above and beyond seeing and hearing and thus laid the foundations for thinking about metacognition long before (Sandí-Ureña, 2008) [159]."

Thus, in this study we form a hypothesis that making someone aware (metacognitive) of systems thinking patterns (DSRP) would increase cognitive complexity (a.k.a., a quantitative measure of the emergent property of systems thinking). Therefore, the hypothesis of this study is that *metacognitive awareness of each of the isolated patterns of DSRP (D, S , R, and P) will have a significant effect on the cognitive complexity/systems thinking of a participant's thoughts on a simple task.*

In what follows, we review the methods used for the four sub-studies (each isolating a pattern of DSRP), the results of these studies, and a discussion of these results. At the end, we summarize our findings.

2. Methods

Statistical analysis was performed using R (v3.6.3). Counts and percentages were used to summarize the distribution of categorical variables. The median and interquartile range were used to summarize the distribution of continuous variables. Wilcoxon signed-rank test was used to compare the distribution of raw counts, words, and characters between time points. Mixed Poisson and negative binomial regression were used to compare the distribution of counts, words, and characters between time points after adjusting for age, gender, race, and ethnicity. Hypothesis testing was performed at 5% level of significance.

The samples used in these studies were broken into four non-duplicative groups (N = 350 per study, N = 1400 across all four) who represented a normal distribution in the US population based on gender, education level, race, ethnicity, region (rural/urban/suburban), and age, balanced to match the census (general population).

In the study, the participants were shown a generic but detailed image of a fish tank (Figure 4).

Figure 4. Fish tank image used in the experiments.

For the first part ("Pre") the participants were shown the above image on a screen and instructed to "Describe what you see in the image". After they had written their answers, depending on the pattern they were randomly assigned to, they were taken to another screen.

For the Distinction study, after the participants filled in their answers in the PreD section, they were asked to read a "Distinction-making-prime" shown in Table 2.

Table 2. Distinction treatment.

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

Then participants were shown the same fish tank image again and asked, "Describe what you see in the image when applying the Distinction Rule you just learned (text copied below the image)". This was called the Post-Distinction-making-prime (or "PostD").

For the Systems study, after the participants filled in their answers in the PreS section, they were asked to read a "Systems-prime" shown in Table 3.

Table 3. Systems treatment.

Things to consider from the part–whole Systems Rule (S): • Systems are all around us, it's how ideas or objects are organized, grouped or nested with one another. • The part–whole structure of systems means that any object or idea is both a part and a whole simultaneously (e.g., a planet is comprised of land and water and is also part of the solar system). • In any whole system, you want to identify the relevant parts to better understand that system. • The systems rule tells us that we can "zoom in" to see more parts and "zoom out" to see more wholes (e.g., zoom in to see the land and water parts of a planet, zoom out to see that planet as part of the solar system).

Then participants were shown the same fish tank image again and asked, "Describe what you see in the image when applying the Systems Rule you just learned (text copied below the image)". This was called the Post-Systems-prime (or "PostS").

For the Relationship study, after the participants filled in their answers in the PreR section, they were asked to read a "Relationship-prime" shown in Table 4.

Table 4. Relationships treatment.

Things to consider from the action–reaction Relationships Rule (R): • The 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. • The 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).

Then participants were 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-prime (or "PostR").

For the Perspectives study, after the participants filled in their answers in the PreP section, they were asked to read a "Perspectives-prime" shown in Table 5.

Table 5. Perspectives treatment.

Things to consider from the point-view Perspectives Rule (P):

- The Perspectives rule reminds us to examine systems from multiple perspectives to better understand any system.
- The point–view structure of Perspectives means that any object or idea can be a point and/or a view (e.g., A person (point) can see another person (view); or different states (point) see the parts of marriage (view) differently).
- The Perspectives Rule encourages us to take both perspectives "with eyes" (e.g., people, stakeholders, groups, countries, animals) but also non-human perspectives (e.g., economic, political, historical, structural, strengths, weaknesses, color, etc.).
- When you change the way you look at things (Perspective), the things you look at change (e.g., the Southern perspective on the Civil War includes different things than the Northern perspective on the Civil War).
- Perspectives can be used as a frame on a system that can either limit/narrow or expand/widen what you see (e.g., looking only at a system from an economic-impact perspective limits what is included while taking a holistic perspective broadens the view).

Then participants were shown the same fish tank image again and asked, "Describe what you see in the image when applying the point-view Perspectives Rule you just learned (text copied below the image)". This was called the Post-Perspectives-prime (or "PostP").

3. Results

We measured the average time to read the treatment which is shown in Table 6. All read-times were less than one minute and together totaled 165.61 s or 2.76 min. To measure the shift in responses from PreX to PostX, a number of strategies were applied to eight different measures. We utilized counts of characters, words, and syllables of the raw data. Word clouds were used in both a qualitative and quantitative manner. Unique words were analyzed in the same way as the raw data. We also performed a textual analysis of word types and their synonyms. Lastly, we did a statistical analysis of the variance between the PreX and PostX conditions.

Table 6. Treatment read-time averages.

D-treatment	28.11 s
S-treatment	35.19 s
R-treatment	51.91 s
P-treatment	50:40 s
Total	**165.61 s**

The word clouds shown in this paper are quantitative data organized visually. The size of each term signifies the frequency of use of the term. Importantly, according to research by Lewis and Frank [160] word length is a valid indicator of complexity of ideas. Indeed, Lewis and Frank showed that the length of a word in characters is correlated with conceptual complexity. Lewis and Frank write:

Hypothesis 1. *At the pragmatic timescale, we asked whether participants would be biased to assign a relatively long novel word to a conceptually more complex referent.*

Hypothesis 2. *At the language evolution timescale, we asked whether languages tended to encoded conceptually more complex meanings with longer forms.*

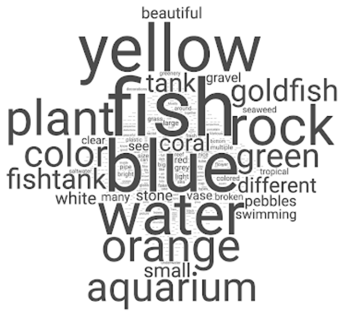
"We found support for both hypotheses".

They showed experimentally that “visual complexity is highly correlated with an implicit measure—reaction time—and this measure predicts the bias to assign an object a long or a short word” (p. 35 [160]). Their experimental research also shows [3] that “explicit measures of conceptual complexity in English are highly correlated with word length in English, and the corpus analysis reveals a correlation between English complexity norms and word lengths in a diverse set of languages” (p. 35 [160]) .

3.1. Distinctions

The quantitative data for the Distinctions (D) study is shown visually in the comparison of word clouds. Below is the PreD and PostD word cloud comparisons (Table 7).

Table 7. Word cloud of response before and after distinction prompt.

PreD	PostD
	

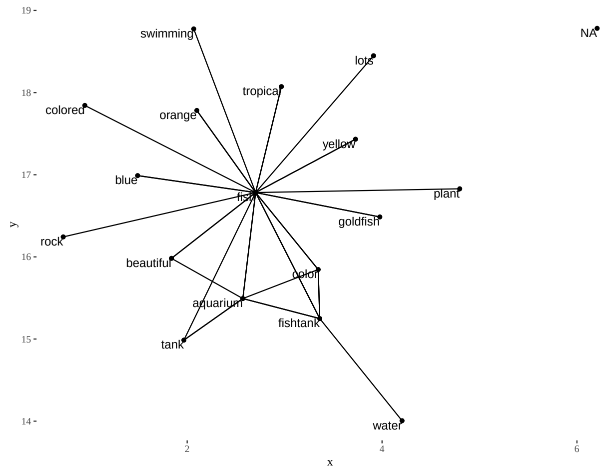
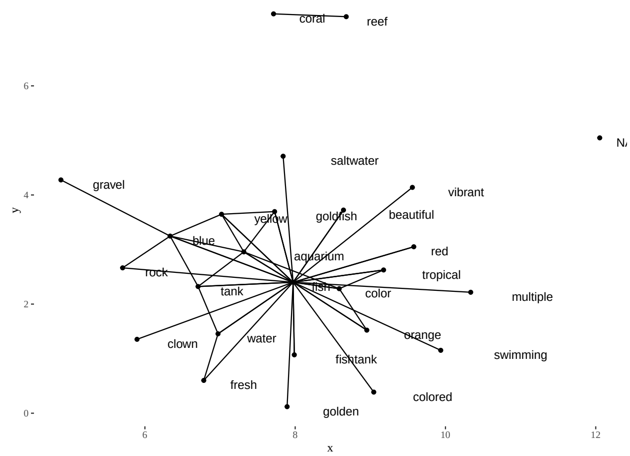
The word clouds in Table 7 explicate the impact of the “Distinction-making prime”. The PostD word cloud is more detailed and more descriptive than the unprimed PreD word cloud. The larger a word is, the more times it is used. In the PostD word cloud adjectives and colors are more prevalent than in the PreD word cloud. PostD also has more unique words overall. The same patterns shown visually in the word clouds are in the quantitative data as well. The PostD responses have significantly more words overall and those words are more complex. Table 8 shows the differences.

Table 8. PreD and PostD aggregate response data.

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

Table 9 shows the correlations between words for Pre and Post D. Two plots show the increased interconnectivity and complexity between words before and after the treatment for Distinction.

Table 9. Correlation between top words used Pre and Post.

PreD	PostD
	

Overall, the PostD responses were more specific than the unprimed PreD responses. This is shown in the word counts and the actual words themselves. It also shows their occurrences and percentage of total occurrences. The top 10 words in the unprimed PreD section is shown in Table 10.

Table 10. Comparison of top 10 words.

PreD Top 10 Words	PostD Top 10 Words
Fish	Fish
Water	Blue
Aquarium	Yellow
Fish tank	Water
Rock	Rock
Plant	Plant
Color	Orange
Blue	Aquarium
Tank	Color
Coral	Green

After being primed with the Distinction pattern of mind, the participants used more descriptive adjectives, in particular, colors. After a very short (<1 min read) the participants increased the specificity of their distinctions. What was once just a "fish" became a "blue fish", "yellow fish", and "orange fish". Table 11 lays out the top 40 words for the PreD and the PostD responses.

Table 11. PreD and PostD top 40 terms used.

	PreD (Total 1848)			PostD (Total 2695)		
Rank	**Word**	**Occurs**	**%**	**Word**	**Occurs**	**%**
1	fish	410	22.19%	fish	542	20.11%
2	water	124	6.71%	blue	145	5.38%
3	aquarium	118	6.39%	yellow	115	4.27%
4	fish tank	92	4.98%	water	114	4.23%
5	rock	85	4.60%	rock	98	3.64%
6	plant	84	4.55%	plant	80	2.97%
7	color	65	3.52%	orange	74	2.75%
8	blue	52	2.81%	aquarium	66	2.45%
9	tank	43	2.33%	color	56	2.08%
10	coral	41	2.22%	green	47	1.74%
11	yellow	27	1.46%	goldfish	42	1.56%
12	stone	24	1.30%	tank	40	1.48%
13	see	22	1.19%	fish tank	40	1.48%
14	beautiful	20	1.08%	coral	35	1.30%
15	tropical	17	0.92%	different	31	1.15%
16	orange	17	0.92%	small	27	1.00%
17	gravel	16	0.87%	white	22	0.82%
18	goldfish	15	0.81%	beautiful	20	0.74%
19	pebbles	15	0.81%	stone	19	0.71%
20	different	13	0.70%	pebbles	19	0.71%
21	lots	12	0.65%	gravel	17	0.63%
22	grass	11	0.60%	swimming	17	0.63%
23	swimming	11	0.60%	with	17	0.63%
24	some	11	0.60%	see	17	0.63%
25	seaweed	10	0.54%	many	16	0.59%
26	decorations	10	0.54%	vase	16	0.59%
27	very	9	0.49%	clear	15	0.56%
28	filter	9	0.49%	that	13	0.48%
29	tree	8	0.43%	broken	12	0.45%
30	green	8	0.43%	very	12	0.45%
31	clean	8	0.43%	red	12	0.45%
32	fake	8	0.43%	tropical	11	0.41%
33	pipe	7	0.38%	seaweed	11	0.41%
34	many	7	0.38%	vs	10	0.37%
35	vase	7	0.38%	grey	10	0.37%
36	nice	7	0.38%	colored	9	0.33%
37	sand	7	0.38%	light	9	0.33%
38	life	6	0.32%	large	9	0.33%
39	like	6	0.32%	multiple	8	0.30%
40	colored	6	0.32%	pipe	8	0.30%

Results in Tables 12 and 13 show that the distribution of number of concepts (i.e., the number of individual entries the subject made, "raw data") was not significantly different before and after treatment ($p = 0.062$ using Wilcoxon signed-rank test). Data (N = 383) were summarized using median (IQR). Statistical analysis was performed using Wilcoxon-signed rank test. However, the median number of words used after treatment (Mdn = 6, IQR 3–10) was significantly higher than the median number of words used before treatment (Mdn = 4, IQR 3–7, $p < 0.001$ ***). Similarly, the median number of characters used after treatment (M = 29, IQR 14–53) was significantly higher than the median number of characters used before treatment (Mdn = 12, IQR 13–36, $p < 0.001$ ***).

Table 12. Distribution of words and characters (vertical lines represent median) for Distinctions (D).

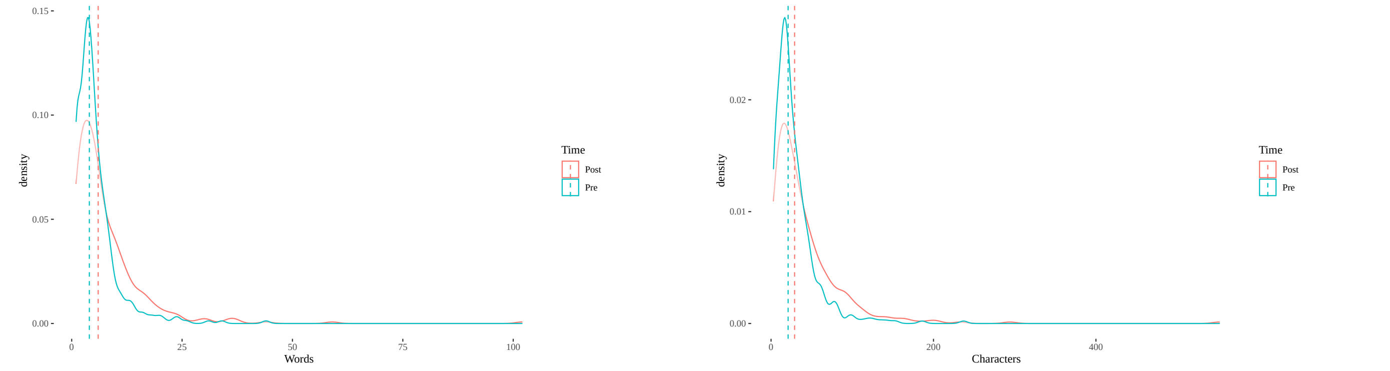


Table 13. Comparison of raw counts, words, and characters before and after D-treatment.

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

Figure 5 shows the difference in the use of any given word (x-axis) between Post and Pre. Data were filtered to only include words mentioned more than five times, such that positive numbers indicate higher word counts post treatment. A positive number indicates that the word was used more post treatment while a negative indicates the less post treatment. For example, the word blue was used 93 more times post-treatment indicating more refined distinction making.

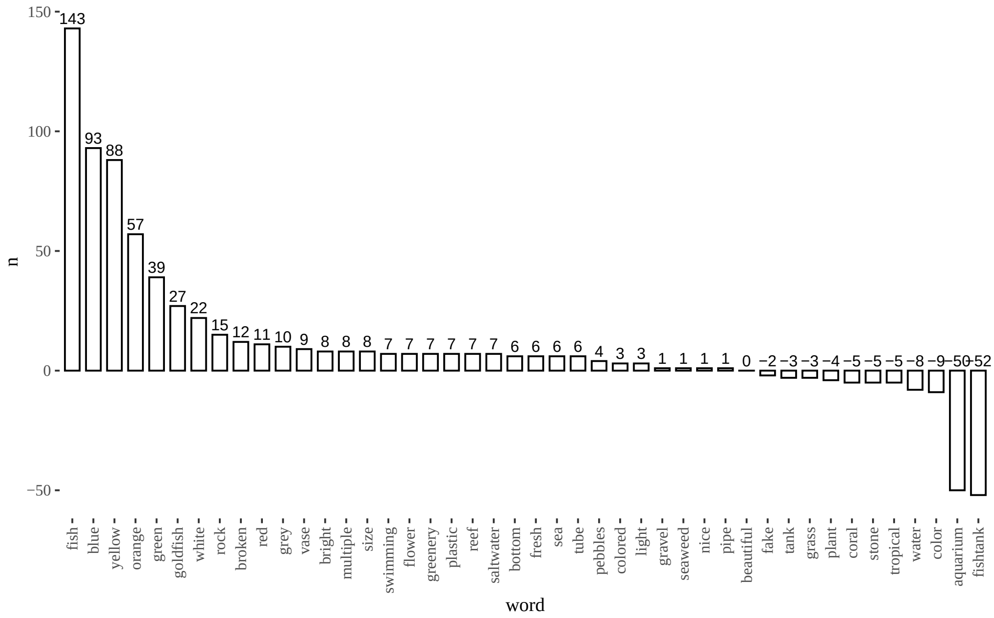


Figure 5. Difference in word count before and after D treatment.

Results in Table 14 show that the expected average count was not significantly different before and after treatment (IRR = 1.05, $p = 0.201$). However, the expected number of words was higher by 43% post-treatment than before treatment (IRR = 1.43, $p < 0.001$ ***). Similarly, the expected average number of characters was higher by 41% post-treatment than pre-treatment (IRR = 1.41, $p < 0.001$ ***). Education and Age were not statistically significant factors in pre-post differences, indicating universality. Male gender was associated with lower expected number of words (IRR = 0.67, p < 0.001 ***) and characters (IRR = 0.69, p < 0.001 ***).

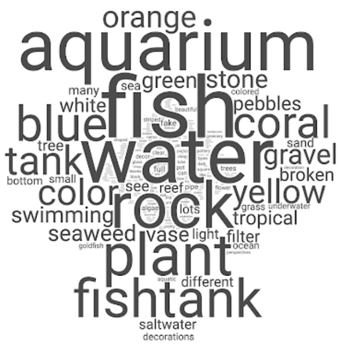
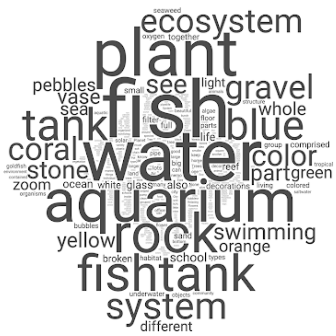
Table 14. D mixed generalized linear regression.

Predictors	No. Concepts Incidence Rate Ratios	p	No. Words Incidence Rate Ratios	p	No. Characters Incidence Rate Ratios	p
(Intercept)	2.69 (1.91–3.77)	**<0.001**	3.07 (2.01–4.69)	**<0.001**	17.31 (11.43–26.21)	**<0.001**
Time (Post vs. Pre)	1.05 (0.97–1.14)	0.201	1.43 (1.34–1.53)	**<0.001**	1.41 (1.31–1.51)	**<0.001**
Age (1 level increase)	0.98 (0.96–1.01)	0.175	1.00 (0.97–1.04)	0.878	1.01 (0.97–1.04)	0.749
Education (1 level increase)	0.00 (0.96–1.04)	0.913	1.00 (0.95–1.05)	0.972	1.00 (0.95–1.04)	0.907
Ethnicity (Not Latino and/or Hispanic)	0.97 (0.81–1.16)	0.750	1.04 (0.83–1.30)	0.734	1.03 (0.83–1.28)	0.803
Gender (Male)	0.89 (0.79–1.00)	0.053	0.67 (0.58–0.78)	<0.001	0.69 (0.60–0.80)	<0.001
Marginal R^2/Conditional R^2	0.013/0.365		0.107/0.664		0.095/0.621	

3.2. Systems

The quantitative data for the Systems (S) study is shown visually in the comparison of word clouds. Below is the PreS and PostS word cloud comparisons (Table 15).

Table 15. Word cloud of response before and after system prompt.

PreS	PostS
	

The word clouds in Table 15 demonstrate the impact of the Systems prime. The PostS word cloud is more detailed and more descriptive than the unprimed PreS word cloud. The larger a word is, the more times it is used. Certain terminologies—such as *ecosystem*, *system*, *whole*, *zoom*, and *part*—are much more prevalent in the PostS and nonexistent in PreS. PostS also has more unique words overall. The same patterns shown visually in the word clouds are in the quantitative data as well. The responses in the PostS have significantly more words overall and those words are more complex. Table 16 shows the quantitative data analysis.

Overall, the PostS responses were more "systemic" than the unprimed PreS responses. This is shown in the words themselves including: *system (38)*, *part (23)*, *whole (16)*, *contain (12)*, *zoom (12)*, *group (8)*, *habitat (6)*, *together (6)*, *community (4)*, *environment (4)*, *organisms (4)*, *organized (2)*, *entirety (2)*, *biosystem (1)*, *gestalt (1)*, *microscopic (1)*, *neighborhood (1)*, *population (1)*. These terms make up 7.44% of the total words in the PostS data.

After being primed with the systems pattern of mind, the participants used more systemic language. They were more focused on part–whole aspects of the fish tank image. After a very short (<1 min read) the participants increased their focus on systems. Table 17 lays out the top 40 words for the PreS and the PostS responses. It also shows their occurrences and percentage of total occurrences.

Table 16. PreS and PostS aggregate response data.

	PreS	PostS	Difference
Number of characters (including spaces)	17,061	19,367	+11.91%
Number of characters (without spaces)	10,318	11,350	+9.09%
Number of words (including repeated words)	2092	2410	+13.20%
Number of syllables (including repeated words)	3207	3654	+12.23%
Unique words	243	416	+41.59%
Number of characters (no spaces) for unique words	1226	2414	+49.21%
Number of syllables for unique words	472	828	+43.00%
Total unique words occurrence	1911	2009	+4.88%

Table 17. PreS and PostS top 40 terms used.

	PreS (Total 1911)			PostS (Total 2009)		
Rank	Word	Occurs	%	Word	Occurs	%
1	fish	416	19.78%	fish	305	12.66%
2	water	136	6.47%	water	145	6.02%
3	aquarium	131	6.23%	aquarium	92	3.82%
4	rock	94	4.47%	plant	92	3.82%
5	plant	86	4.09%	rock	68	2.82%
6	fish tank	77	3.66%	fish tank	56	2.32%
7	blue	61	2.90%	tank	44	1.83%
8	coral	57	2.71%	and	40	1.66%
9	color	41	1.95%	blue	39	1.62%
10	tank	39	1.85%	system	38	1.58%
11	yellow	35	1.66%	color	27	1.12%
12	gravel	31	1.47%	ecosystem	27	1.12%
13	orange	31	1.47%	coral	24	1.00%
14	and	28	1.33%	gravel	24	1.00%
15	stone	22	1.05%	part	23	0.95%
16	with	22	1.05%	see	19	0.79%
17	seaweed	17	0.81%	stone	18	0.75%
18	green	16	0.76%	with	18	0.75%
19	swimming	16	0.76%	swimming	16	0.66%
20	pebbles	15	0.71%	vase	16	0.66%
21	tropical	15	0.71%	whole	16	0.66%
22	vase	15	0.71%	yellow	15	0.62%
23	decorations	14	0.67%	pebbles	13	0.54%
24	white	14	0.67%	sea	13	0.54%
25	broken	13	0.62%	contain	12	0.50%
26	filter	13	0.62%	green	12	0.50%
27	reef	12	0.57%	orange	12	0.50%
28	see	11	0.52%	this	12	0.50%
29	different	10	0.48%	zoom	12	0.50%
30	light	10	0.48%	decorations	11	0.46%
31	saltwater	10	0.48%	school	11	0.46%
32	tree	10	0.48%	different	10	0.41%
33	lots	9	0.43%	on	10	0.41%
34	on	9	0.43%	bubbles	9	0.37%
35	sand	9	0.43%	light	9	0.37%
36	sea	9	0.43%	living	9	0.37%
37	bottom	8	0.38%	also	8	0.33%
38	many	8	0.38%	glass	8	0.33%
39	small	8	0.38%	group	8	0.33%
40	grass	7	0.33%	life	8	0.33%

Results in Figure 6 and Table 18 show that the distribution of concepts was significantly different before and after treatment (p =< 0.001 *** using Wilcoxon signed-rank test). Data was summarized using median (IQR). Statistical analysis was performed using

Wilcoxon-signed rank test. The distribution of the number of words and characters was not significantly different before and after treatment.

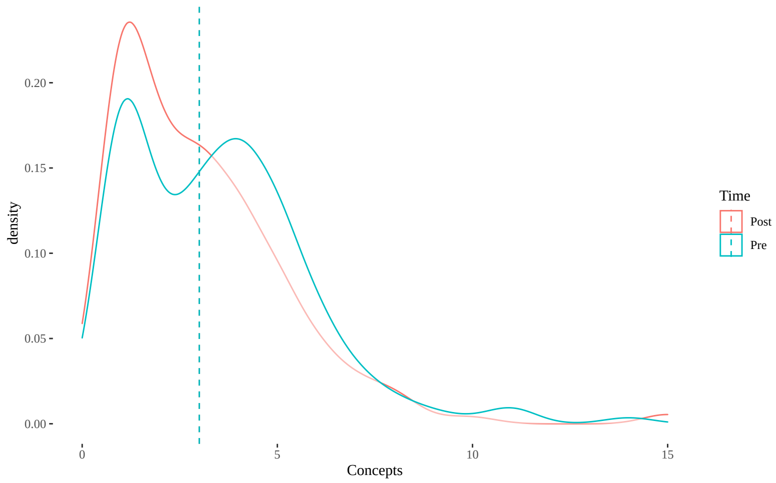


Figure 6. Distribution of Systems (S) concepts (vertical lines represent median).

Table 18. S comparison of raw counts, words, and characters before and after treatment.

	Pre	Post	P.overall
No. concepts	3.00 [1.00; 5.00]	3.00 [1.00; 4.00]	**<0.001**
No. words	4.00 [3.00; 7.00]	4.00 [2.00; 7.00]	0.13
No. characters	23.0 [14.0; 35.8]	22.0 [13.0; 39.0]	0.13

Figure 7 shows the difference in the use of any given word (x-axis) between Post and Pre. Data were filtered to only include words mentioned more than five times, such that positive numbers indicate higher word counts post treatment. A positive number indicates that the word was used more post treatment while a negative indicates the less post treatment. For example, the word system was used 34 more times and the word ecosystem was used 23 more times post-treatment indicating that subjects identified systemic concepts with part–whole structure.

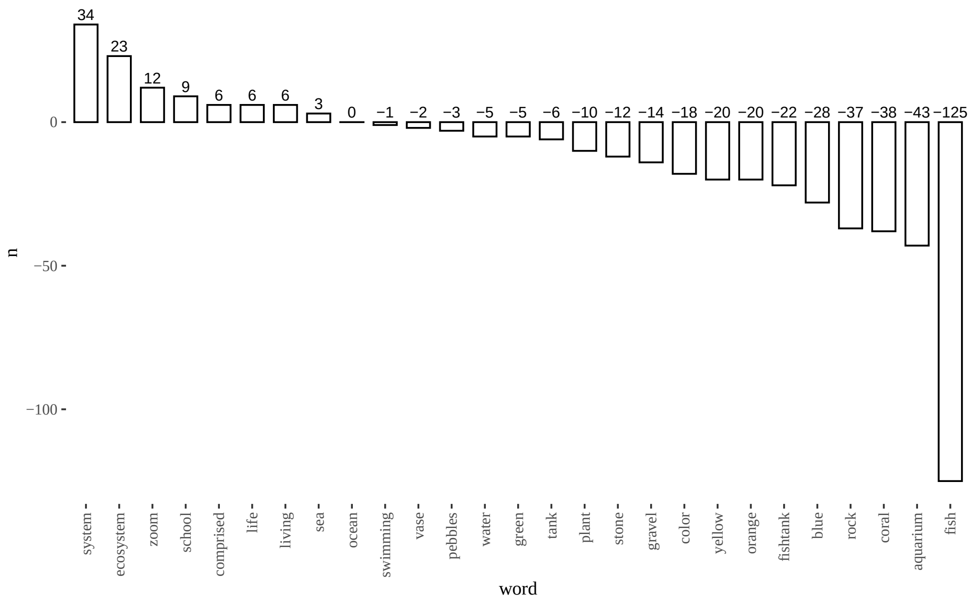


Figure 7. Difference in word count before and after S treatment.

Table 19. S mixed generalized linear regression.

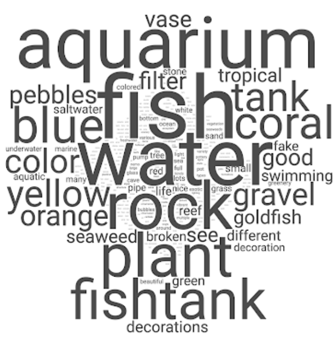
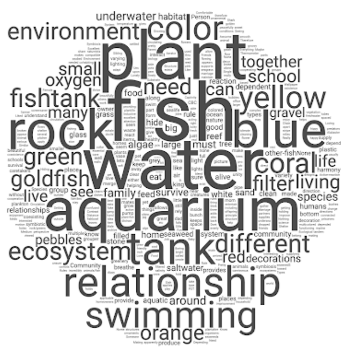
Predictors	No. Concepts Incidence Rate Ratios	p	No. Words Incidence Rate Ratios	p	No. Characters Incidence Rate Ratios	p
Time (Post vs. Pre)	0.87 (0.81–0.95)	**<0.001**	1.12 (1.02–1.22)	**0.015**	1.08 (0.99–1.17)	0.091
Age (1 level increase)	1.02 (0.99–1.04)	0.259	1.06 (1.03–1.10)	**<0.001**	1.06 (1.03–1.10)	**<0.001**
Education (1 level increase)	0.99 (0.95–1.03)	0.579	1.00 (0.96–1.05)	0.847	1.01 (0.97–1.06)	0.622
Ethnicity (Not Latino and/or Hispanic)	1.06 (0.88–1.28)	0.538	0.99 (0.79–1.25)	0.959	0.98 (0.79–1.22)	0.847
Gender (Male)	0.93 (0.82–1.05)	0.253	0.85 (0.73–0.99)	**0.039**	0.85 (0.73–0.98)	0.027
Marginal R^2/Conditional R^2	0.017/0.399		0.039/0.483		0.040/0.470	

Data were analyzed (19) using Poisson regression for concepts and using negative binomial regression for words and characters. Results showed that the expected number of concepts was lower by 13% after treatment than before treatment (IRR = 0.87, $p < 0.001$ ***). However, the expected number of words was higher by 12% post-treatment than before treatment (IRR = 1.12, $p = 0.015$ **). The expected number of characters was higher by 8% post-treatment than pre-treatment (IRR = 1.06, $p = 0.091$) although the result was statistically significant at the 0.1 level only. Male gender and younger age were associated with an overall lower number of words and characters. Ethnicity and education were not significantly different before and after intervention.

3.3. Relationships

The data for the Relationships (R) study is applied visually in the comparison of word clouds. Below is the PreR and PostR word cloud comparisons (Table 20).

Table 20. Word cloud of response before and after relationships prompt.

PreR	PostR
	

The above word clouds demonstrate the impact of the "Relationships prime". The PostR word cloud is more detailed and more descriptive than the unprimed PreR word cloud. The larger a word is, the more times it is used. Smaller words indicate more overall detail and more words used among each participant. Relational words—like *relationship*, *and*, *to*, *between*—are shown in the PostR and nonexistent in the PreR data. PostR also has more unique words overall. The same patterns shown visually in the word clouds are in the quantitative data as well. The responses in the PostR have significantly more words overall and those words are more relational. Table 21 shows the quantitative data analysis.

Overall, the PostR responses were more interrelational than the unprimed PreR responses. This is shown in the actual words used by the participants. This includes "connector" words such as: *and (78), in (67), of (61), to (61), relationship (41), are (32), for (24), with (20), different (16), between (16)*. 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 the PostR data than in PreR.

Table 21. PreR and PostR aggregate response data.

	PreR	PostR	Difference
Number of characters (including spaces)	18,443	21,965	+16.03%
Number of characters (without spaces)	11,271	13,132	+14.17%
Number of words (including repeated words)	2248	2814	+20.11%
Number of syllables (including repeated words)	3532	2814	+20.11%
Unique words	279	466	+40.13%
Number of characters (no spaces) for unique words	1578	2684	+41.21%
Number of syllables for unique words	537	926	+42.01%
Total unique words occurrence	2138	2553	+16.26%

Table 22 lays out the top 40 words for the PreR and the PostR responses. It also shows their occurrences and percentage of total occurrences. The PostR condition includes many more connector words than the PreR.

Table 22. PreR and PostR top 40 terms used.

	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	fish tank	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%	fish tank	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%

Data (N = 382) were summarized using median (IQR). Statistical analysis was performed using Wilcoxon-signed rank test. Results in in Figures 8–10 and Table 23 show that the distribution of concepts was significantly different before and after treatment (p = < 0.001 *** 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 *).

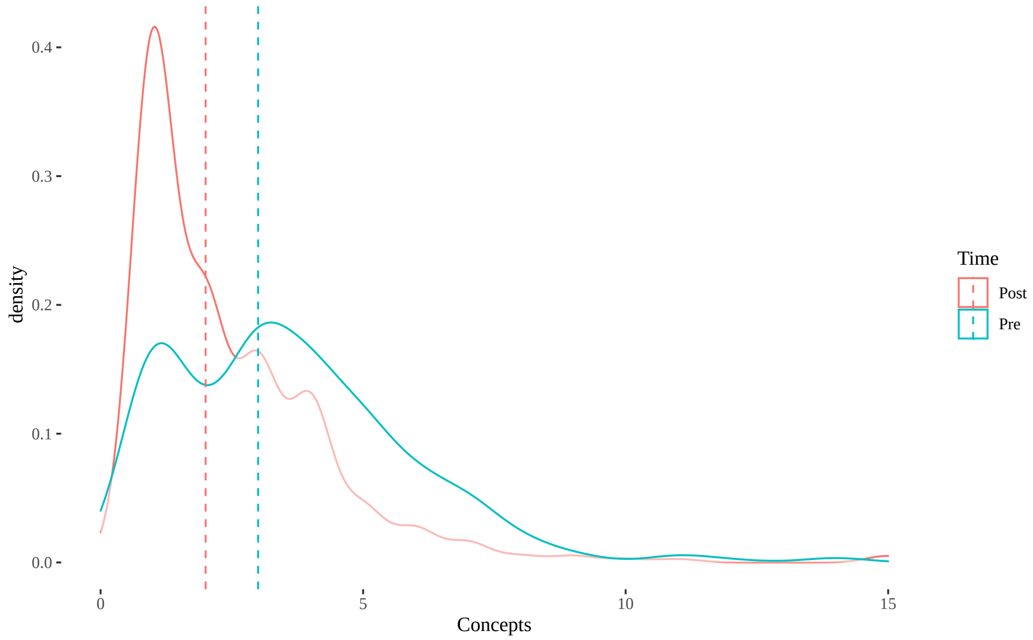


Figure 8. Distribution of concepts for PreR and PostR (vertical lines represent median).

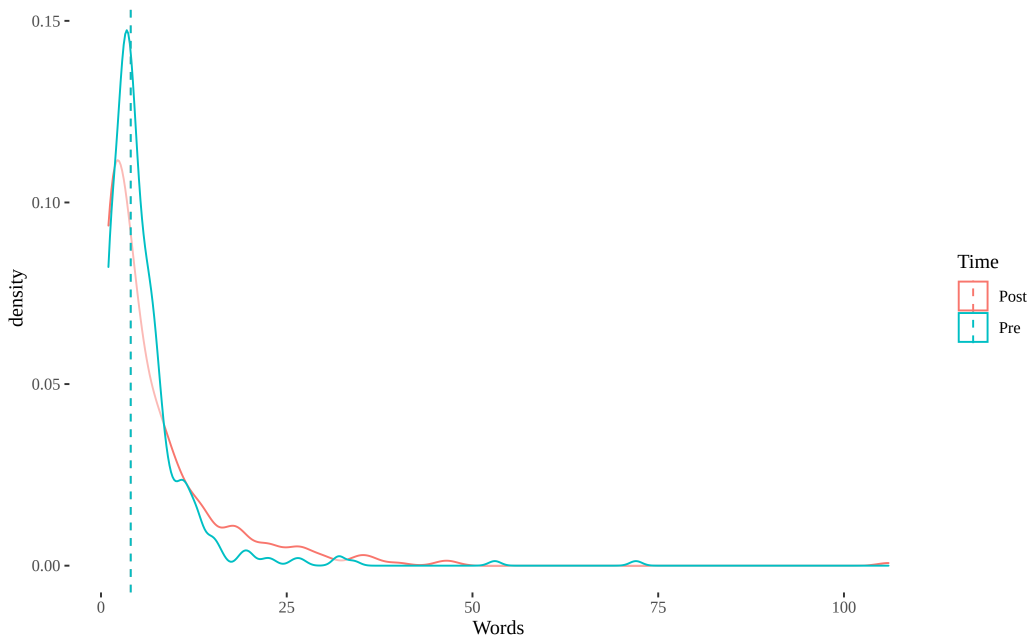


Figure 9. Distribution of words for PreR and PostR (vertical lines represent median).

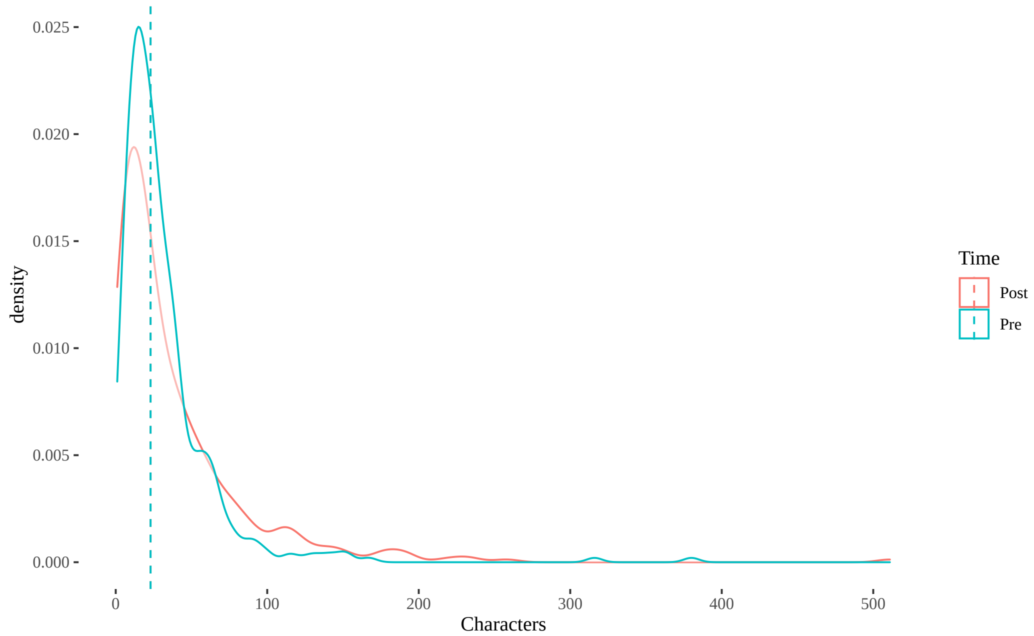


Figure 10. Distribution of characters for PreR and PostR (vertical lines represent median).

Table 23. R comparison of raw counts, words, and characters before and after treatment.

	Pre	Post	P.overall
No. concepts	3.00 [2.00; 5.00]	2.00 [1.00; 3.00]	**<0.001**
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**

Figure 11 shows the difference in the use of any given word (x-axis) between Post and Pre. Data were filtered to only include words mentioned more than five times, such that positive numbers indicate higher word counts post treatment. A positive number indicates that the word was used more post treatment while a negative indicates the less post treatment. For example, the word *relationship* was used 29 more times and the word *swimming* was used 15 more times post-treatment indicating that subjects identified *relational* concepts more often.

Data were analyzed (Table 24) using Poisson regression for concepts and using negative binomial regression for words and characters. Results showed that the expected number of concepts was lower by 30% after treatment than before treatment (IRR = 0.69, $p < 0.001$ ***). However, the expected number of words was higher by 21% post-treatment than before treatment (IRR = 1.21, $p < 0.001$ ***). Similarly, the expected number of characters was higher by 14% post-treatment than pre-treatment (IRR = 1.14, $p = 0.004$ **). Male gender, and younger age were associated with an overall lower number of words and characters. Ethnicity and education were not significantly different before and after intervention.

Table 24. R mixed generalized linear regression.

	No. Concepts		No. Words		No. Characters	
Predictors	Incidence Rate Ratios	*p*	Incidence Rate Ratios	*p*	Incidence Rate Ratios	*p*
Time (Post vs. Pre)	0.69 (0.63–0.75)	**<0.001**	1.21 (1.11–1.32)	**<0.001**	1.14 (1.04–1.24)	**0.004**
Age (1 level increase)	1.00 (0.97–1.03)	0.948	1.03 (1.00–1.07)	**0.050**	1.04 (1.00–1.07)	**0.031**
Education (1 level increase)	0.99 (0.95–1.02)	0.511	1.01 (0.96–1.06)	0.668	1.01 (0.96–1.06)	0.752
Ethnicity (Not Latino and/or Hispanic)	1.00 (0.85–1.17)	0.962	1.06 (0.85–1.32)	0.597	1.04 (0.84–1.28)	0.728
Gender (Male)	0.93 (0.83–1.05)	0.251	0.75 (0.65–0.88)	**<0.001**	0.77 (0.66–0.89)	**<0.001**
Marginal R2 / Conditional R2	0.076/0.370		0.051/0.517		0.041/0.481	

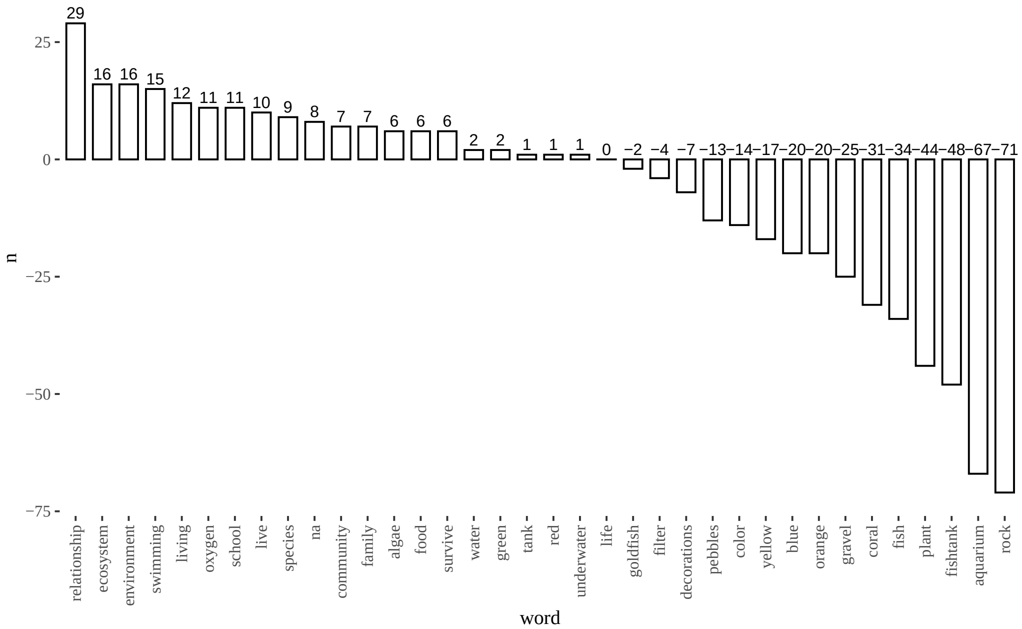
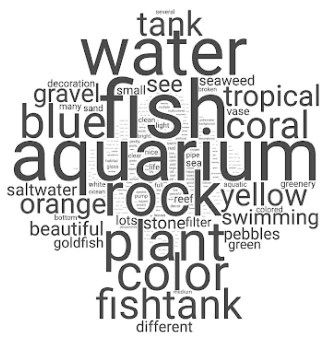
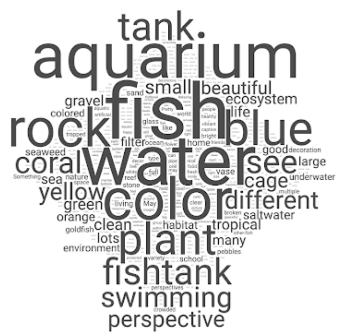


Figure 11. Difference in word count before and after R treatment.

3.4. Perspectives

The data for the Perspectives (P) study is shown visually in the comparison of word clouds. Below is the PreP and PostP word cloud comparisons (Table 25).

Table 25. Word cloud of response before and after perspective prompt.

PreP	PostP
	

The word clouds show the significant impact of the Perspectives prime. The PostP word cloud is more detailed and more descriptive than the unprimed PreP word cloud. The larger a word is, the more times it is used. There are perspectival words—such as *perspectives* and *see*—in the PostP data that are nonexistent in the PreP data. PostP also has more unique words overall. The same patterns shown visually in the word clouds are in the quantitative data as well. The responses in the PostP have significantly more words overall and those words are more perspectival. Table 26 shows the quantitative data analysis.

Table 27 lays out the top 40 words for the PreP and the PostP responses. It also shows their occurrences and percentage of total occurrences. The PostP condition includes many more unique words than the PreP. Perspectival words made up significantly more of the PostP total than in the PreP condition including words like: see (41), perspective (25), and cage (18).

Table 26. PreP and PostP aggregate response data.

	PreP	PostP	Difference
Number of characters (including spaces)	19,758	22,371	+11.68%
Number of characters (without spaces)	12,336	13,794	+10.57%
Number of words (including repeated words)	2513	2915	+13.79%
Number of syllables (including repeated words)	3967	4483	+11.51%
Unique words	276	497	+44.47%
Number of characters (no spaces) for unique words	1598	2914	+45.16%
Number of syllables for unique words	533	991	+46.22%
Total unique words occurrence	2089	2322	+10.03%

Table 27. PreP and PostP top 40 terms used.

	PreP (Total 2089)			PostP (Total 2322)		
Rank	**Word**	**Occurs**	**%**	**Word**	**Occurs**	**%**
1	fish	403	19.29%	fish	350	15.07%
2	aquarium	142	6.80%	water	106	4.57%
3	water	138	6.61%	aquarium	90	3.88%
4	rock	97	4.64%	color	86	3.70%
5	color	94	4.50%	rock	57	2.45%
6	plant	88	4.21%	blue	48	2.07%
7	blue	68	3.26%	plant	45	1.94%
8	fish tank	60	2.87%	tank	42	1.81%
9	coral	51	2.44%	see	41	1.77%
10	tank	45	2.15%	fish tank	38	1.64%
11	yellow	37	1.77%	swimming	29	1.25%
12	orange	28	1.28%	coral	26	1.12%
13	tropical	28	1.34%	perspective	25	1.08%
14	gravel	27	1.29%	with	23	0.99%
15	many	24	1.15%	different	22	0.95%
16	see	23	1.10%	yellow	21	0.90%
17	swimming	21	1.01%	cage	18	0.78%
18	beautiful	18	0.86%	small	18	0.78%
19	pebbles	17	0.81%	beautiful	17	0.73%
20	saltwater	16	0.77%	be	16	0.69%
21	stone	16	0.77%	clean	15	0.65%
22	different	15	0.72%	ecosystem	15	0.65%
23	goldfish	15	0.72%	there	15	0.65%
24	seaweed	15	0.72%	decoration	14	0.60%
25	decoration	13	0.62%	green	14	0.60%
26	filter	13	0.62%	gravel	13	0.56%
27	green	13	0.62%	life	13	0.56%
28	small	12	0.57%	tropical	13	0.56%
29	reef	11	0.53%	filter	12	0.52%
30	vase	11	0.53%	lots	12	0.52%
31	greenery	10	0.48%	many	12	0.52%
32	sand	9	0.43%	other	12	0.52%
33	some	9	0.43%	sea	12	0.52%
34	life	8	0.38%	large	11	0.47%
35	sea	8	0.38%	orange	11	0.47%
36	aquatic	7	0.34%	saltwater	11	0.47%
37	bottom	7	0.34%	that	11	0.47%
38	clean	7	0.34%	environment	10	0.43%
39	light	7	0.34%	habitat	10	0.43%
40	nice	7	0.34%	home	10	0.43%

Data (N = 362) were summarized using median (IQR). Statistical analysis was performed using Wilcoxon-signed rank test. Results in Figures 12–14 and Table 28 show that the distribution of concepts was significantly different before and after treatment

($p = 0.002$ ** using Wilcoxon signed-rank test) with a lower average number of concepts observed after treatment. The median number of words used after treatment (Mdn = 6, IQR 3–10) was significantly higher than the median number of words used before treatment (Mdn = 5, IQR 3–8, $p = 0.064$) although the result was statistically significant at the 0.1 level. The median number of characters used after treatment (Mdn = 32, IQR 19–59) was significantly higher than the median number of words used before treatment (Mdn = 28, IQR 18–45, $p = 0.013$ **).

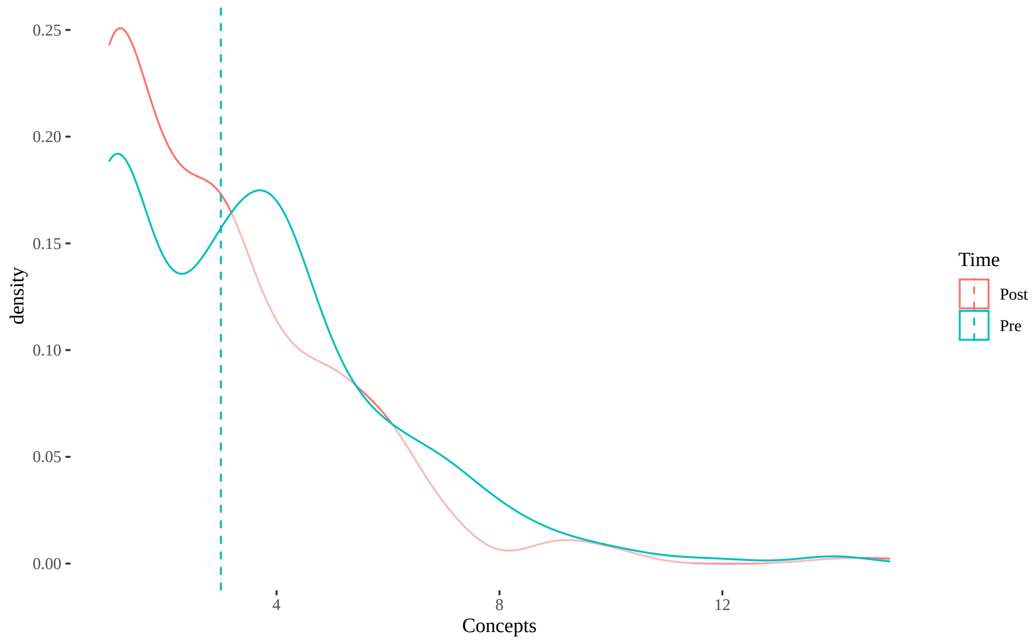


Figure 12. Distribution of concepts for PreP and PostP (vertical lines represent median).

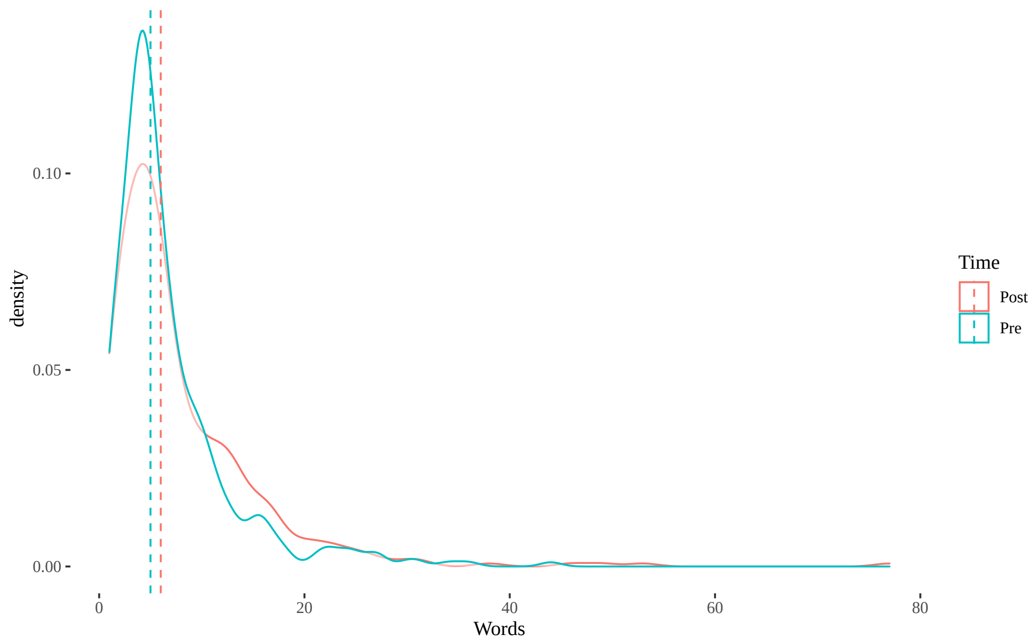


Figure 13. Distribution of words for PreP and PostP (vertical lines represent median).

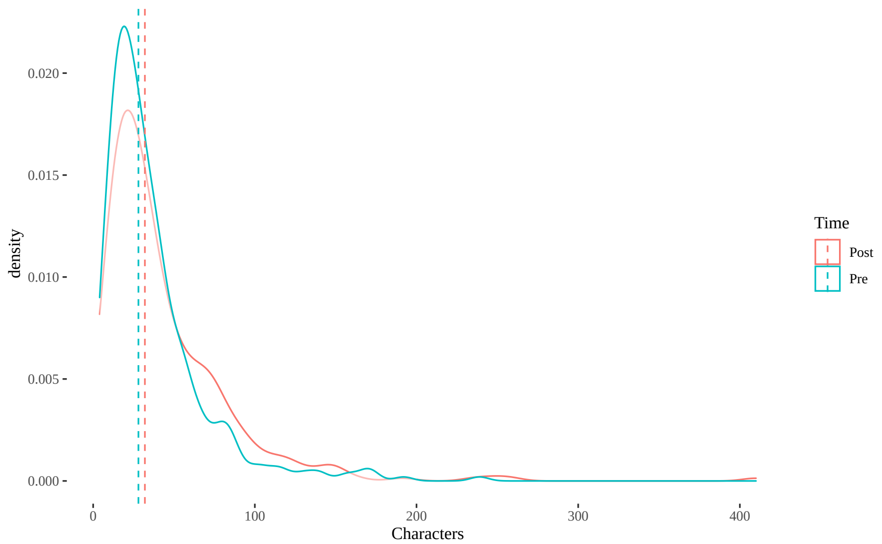


Figure 14. Distribution of characters for PreP and PostP (vertical lines represent median).

Table 28. Comparison of raw counts, words, and characters before and after P treatment.

	Pre	Post	P.overall
No. concepts			
Median [IQR]	3.00 [1.00; 5.00]	3.00 [1.00; 4.00]	**0.002**
Mean (SD)	3.51 (2.36)	2.99 (2.15)	**0.002**
	3.00 [1.00; 4.00]	3.00 [1.00; 4.00]	0.062
No. words	5.00 [3.00; 8.00]	6.00 [3.00; 10.0]	0.064
No. characters	28.0 [18.0; 45.0]	32.0 [19.0; 58.8]	**0.013**

Figure 15 shows the difference in the use of any given word (x-axis) between Post and Pre. Data were filtered to only include words mentioned more than five times, such that positive numbers indicate higher word counts post treatment. A positive number indicates that the word was used more post treatment while a negative indicates the less post treatment. For example, the word *perspective* was used 20 more times and the word *cage* was used 18 more times post-treatment indicating that subjects took perspective more often.

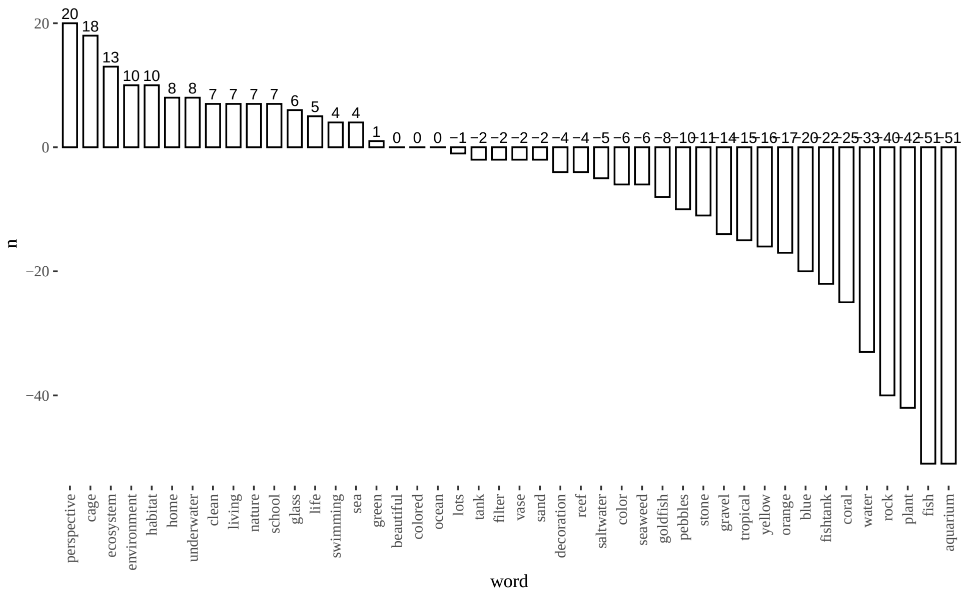


Figure 15. Difference in word count before and after P treatment.

Data were filtered to words mentioned > five times; positive numbers indicate higher count post treatment. Results showed (Table 29) that the expected number of concepts was significantly lower after treatment than before treatment (IRR = 0.85, $p < 0.001$ ***). However, the expected number of words was higher by 17% post-treatment than before treatment (IRR = 1.17, $p < 0.001$ ***). Similarly, the expected number of characters was higher by 19% post-treatment than pre-treatment (IRR = 1.19, $p < 0.001$ ***). Male gender, education, age, and ethnicity were not significantly different before and after intervention.

Table 29. P mixed generalized linear regression.

Predictors	No. Concepts Incidence Rate Ratios	*p*	No. Words Incidence Rate Ratios	*p*	No. Characters Incidence Rate Ratios	*p*
(Intercept)	4.12 (3.25–5.21)	**<0.001**	4.88 (3.68–6.46)	**<0.001**	25.69 (19.66–33.57)	**<0.001**
Time (Post vs. Pre)	0.85 (0.79–0.93)	**<0.001**	1.17 (1.09–1.26)	**<0.001**	1.19 (1.11–1.27)	**<0.001**
Age (1 level increase)	0.97 (0.95–1.00)	0.051	1.01 (0.98–1.04)	0.531	1.02 (0.99–1.05)	0.253
Education (1 level increase)	1.01 (0.97–1.05)	0.688	1.02 (0.97–1.07)	0.429	1.02 (0.97–1.06)	0.439
Ethnicity (Not Latino and/or Hispanic)	0.86 (0.71–1.04)	0.128	1.11 (0.88–1.40)	0.357	1.12 (0.90–1.40)	0.293
Gender (Male)	0.91 (0.80–1.03)	0.119	1.00 (0.86–1.15)	0.982	1.01 (0.88–1.16)	0.837
Marginal R^2/Conditional R^2	0.032/0.394		0.015/0.573		0.021/0.562	

4. Discussion

Subjects were asked to describe a common scene before and after a simple treatment. The results are statistically unambiguous. However, one should consider some of the alternative explanations or mediating variables. There are a number of such things to consider.

For example, the post-treatment condition is the second time subjects were asked to describe the same scene. Thus, one might expect them—due to *familiarity/repetition*—to describe the scene with greater complexity. However, this explanation does not account for the increases in unique words, number of characters of unique words, number of syllables for unique words, and total unique words occurrence. As a mediating variable, familiarity/repetition also does not account for the correlation we see in the top words used Pre and Post. In other words, we see *more* and *better* post treatment. Familiarity/repetition might account for some aspect of the *more*, but not the *better* results. Another way to explain this is that in the post-treatment results, where we saw more and better (both quantitatively and qualitatively), we also saw more of the specific form of thinking: more perspectives, more distinctions, more part–whole structures, more interrelationships. Repetition/familiarity alone would not produce results of this specific nature.

One might also conclude that *intentionality* or a "social-desirability bias" (a form of response bias) played a role in the post-treatment results. For example, it may be that subjects, in their desire to please the researchers or be seen as "good at the task" simply did more post-treatment than pre-treatment. To assume such a mediating factor would be to grossly misunderstand the application of such bias. If we are surveying an individual, for example, on their drug use, one might reasonably expect an under-reporting due to such a bias. However, in this study, we are testing whether being made aware of a cognitive pattern/structure can effectively increase one's cognitive complexity and the systemic nature of their thinking. In this case, *intentionality* is precisely what we are seeking to learn the effect of (a.k.a., metacognition). We are seeking to determine whether being made aware of a cognitive pattern—and therefore intentional in one's thinking—produces a positive effect in the result of one's thinking.

Finally, with regard to mediating factors, consider a hypothetical alternative study where the study design is the same but for one change to the treatment. In this hypothetical example, consider two variants:

1. The treatment is something entirely random such as: Look for orange things such as Cheetos, oranges, basketballs, pumpkins or things that remind you of Cheetos, oranges, basketballs, pumpkins, etc.
2. The treatment is something more purposefully cognitive and structural such as: consider the polarizing arguments that could be made about the scene.

Now consider what we might find in our two *hypothetical* studies and how those findings would differ from those of this study. In the first study (#1 above), one would hypothesize that more subjects would focus on and find more orange things. They would perhaps set their intention to discover more orange things in order to please the researchers. Overall, we would see an increase in orange things seen and described. In the second study (#2 above), one would hypothesize that more subjects would focus on and describe more polarizing aspects of the scene, such as the consideration of animal cruelty vs. pet-loving or agency vs. ownership or saltwater vs. freshwater. They would perhaps set their intention to discover more polarized examples in order to please the researchers. Overall, we would see an increase in the polarized examples described.

In the first hypothetical study, we would get relatively *inconsequential* results due to the *random* nature of the treatment. In the second hypothetical study, we would get relatively *negative* results due to the undesirable nature of the treatment (few of us are seeking ways to increase polarized-thinking). The point of these hypothetical examples is to tease out what is critically important in the fish tank studies described herein: that there is something quite remarkable about the cognitive structures of the treatments. These *particular* DSRP structures—when used purposefully and metacognitively—are neither random nor do they produce undesirable results, but are instead targeted and produce the desirable results of increased cognitive complexity, sophistication, robustness, and systemic thinking.

As just one of eight dimensions of difference between Pre and Post, Figure 16 shows the stark aggregate change from PreDSRP to PostDSRP (in terms of number of words).

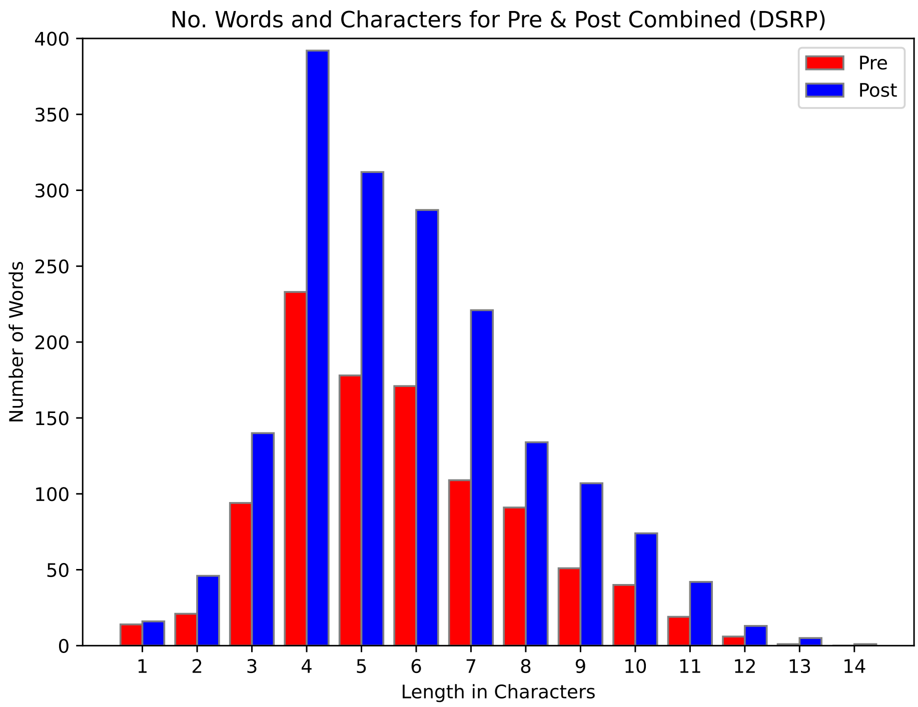


Figure 16. Aggregate DSRP Pre/Post graphical comparison.

Table 30 shows a summary of p-values across all four D, S, R, and P studies.

Table 30. Summary *p*-values for D, S, R, and P Pre and Post treatments.

	p
Identity–Other Distinctions (D)	
No. concepts	0.062
No. words	**<0.001**
No. characters	**<0.001**
Part–Whole Systems (S)	
No. concepts	**<0.001**
No. words	0.13
No. characters	0.13
Action–Reaction Relationships (R)	
No. concepts	**<0.001**
No. words	**0.003**
No. characters	**0.015**
Point–View Perspectives (P)	
No. concepts	**0.002**
No. words	0.064
No. characters	**0.013**

Table 31 summarizes the aggregate differences along eight dimensions across all four D, S, R, and P studies showing a stark difference in the rows and columns of increases (+s). The percentages are the result of of *Post minus Pre* aggregates.

Table 31. Difference for Pre and Post D, S, R, and P.

	D	S	R	P
Number of characters (including spaces)	+27.22%	+11.91%	+16.03%	+11.68%
Number of characters (without spaces)	+30.24%	+09.09%	+14.17%	+10.57%
Number of words (including repeated words)	+31.68%	+13.20%	+20.11%	+13.79%
Number of syllables (including repeated words)	+28.78%	+12.23%	+20.11%	+11.51%
Unique words	+44.59%	+41.59%	+40.13%	+44.47%
Number of characters (no spaces) for unique words	+46.00%	+49.21%	+41.21%	+45.16%
Number of syllables for unique words	+45.39%	+43.00%	+42.01%	+46.22%
Total unique words occurrence	+31.64%	+04.88%	+16.26%	+10.03%

4.1. Distinctions

In Table 30, *p*-value results for Distinctions (D) indicate that there was statistically significant difference in individual subjects in the number of concepts they answered at the 0.1 level. Additionally, there was a highly statistically significant differences in both the number of words and characters. In addition, overall counts (in Table 31) in eight different categories of response data *increased*. This leads us to conclude that the very short treatment had a significant effect on the participant's cognitive complexity. Figure 17 graphically represents the difference between the PreD and PostD data.

These findings indicate *highly statistically significant* and *statistically significant increases* in the degree to which people made more detailed distinctions and more distinctions from just a <1 min treatment. The implications this research has on metacognition and its relationship to cognitive complexity is substantial.

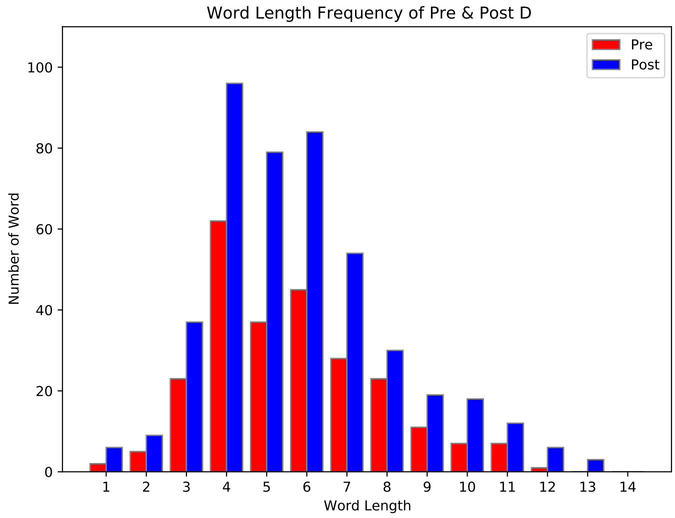


Figure 17. Comparison of PreD and PostD data.

4.2. Systems

In Table 30, *p*-value results for Systems (S) indicate that there was a highly statistically significant difference in individual subjects in the number of concepts they answered, but not in the number of words and characters. This is most likely because listing additional parts would not require additional words and characters (e.g., complexity). For example, listing that a fish had a part "fin" increases the number of concepts but not necessarily words and characters. At the same time, overall counts (in Table 31) in eight different categories of response data *increased*. This leads us to conclude that the very short treatment had a significant effect on the participant's cognitive complexity.

Figure 18 shows the graphical representation of the difference between the PreS and PostS data.

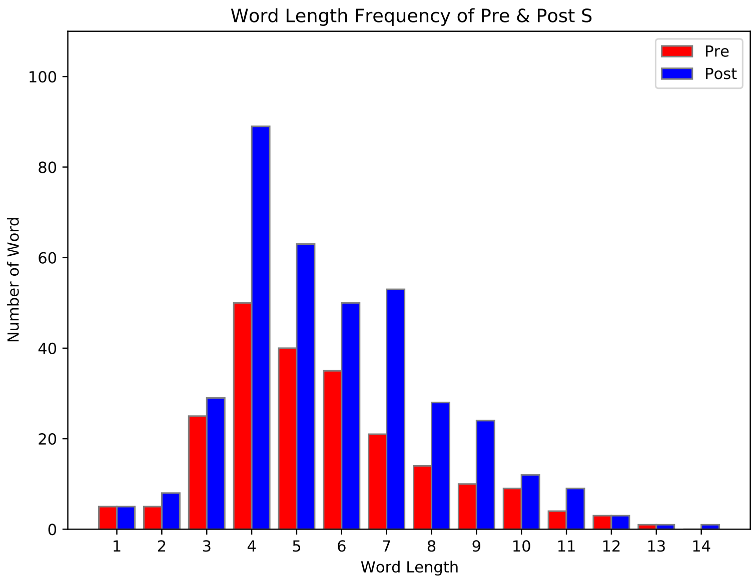


Figure 18. Comparison of PreS and PostS data.

These findings indicate *highly statistically significant* and *statistically significant increases* in the degree to which people made more systemic answers from just a <1 min treatment.

Again, the implications this research has on metacognition and its relationship to cognitive complexity is substantial.

4.3. Relationships

Relationship (R) results in Table 30, show *p*-value results that indicate that there was highly statistically significant difference in individual subjects in the number of concepts, words, and characters. In addition, overall counts (in Table 31) in eight different categories of response data *increased*. This leads us to conclude that the very short treatment had a significant effect on the participant's cognitive complexity. Figure 19 shows the graphical representation of the difference between the PreR and PostR data.

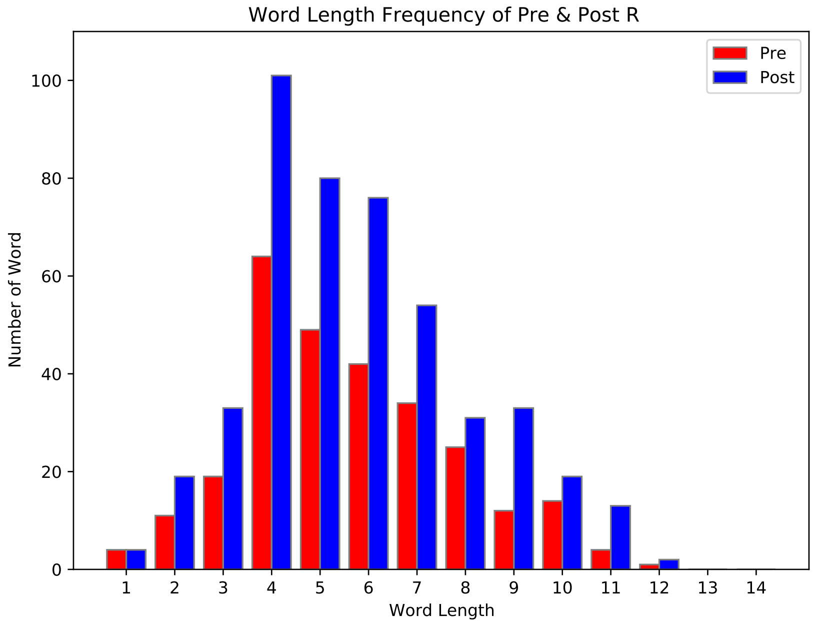


Figure 19. Comparison of PreR and PostR data.

These findings indicate *highly statistically significant increases* in the degree to which people made more interrelational answers from just a <1 min treatment. Again, the implications this research has on metacognition and its relationship to cognitive complexity is substantial.

4.4. Perspectives

Perspective (P) results in Table 30, show *p*-value results that indicate that there was statistically significant difference in individual subjects in the number of concepts and characters but not words. In addition, overall counts (in Table 31) in eight different categories of response data *increased*. This leads us to conclude that the very short treatment had a significant effect on the participant's cognitive complexity. Figure 20 shows the graphical representation of the difference between the PreP and PostP data.

These findings indicate *statistically significant increases* in the degree to which people made take perspectives from just a <1 min treatment. Again, the implications this research has on metacognition of DSRP and its relationship to systems thinking and cognitive complexity are substantial.

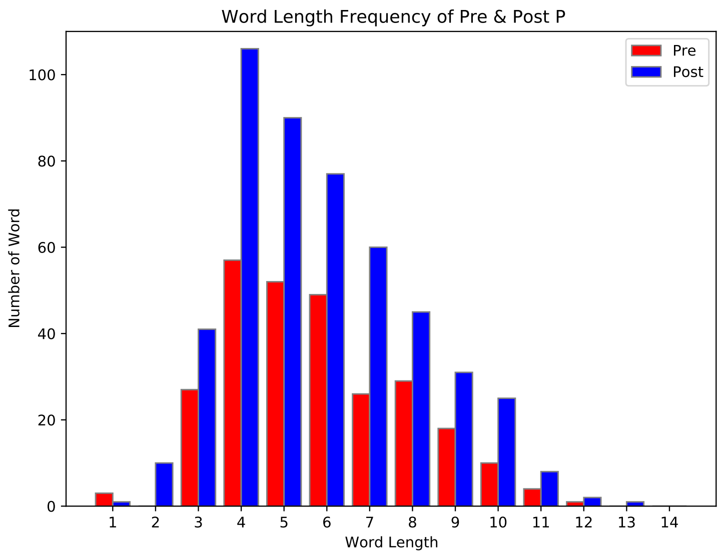


Figure 20. Comparison of PreP and PostP data.

Although it was not the primary focus of this study, there were no statistically significant differences Pre and Post for D, S, R, or P treatments based on either ethnicity or education. This indicates that DSRP is not effected by education or ethnicity, which is interesting given that most "educational" treatments would differ based on ethnicity (e.g., systemic racism in test scores) and education level (e.g., systemic racism in educational attainment)[3]. Whereas, there was a significant difference in S and R for younger individuals, suggesting that DSRP abilities may increase with life experience. There were also significant decreases in D, S, and R for males. Although further research is needed to determine the full scope and meaning of these results, these data may suggest that DSRP is egalitarian.

5. Conclusions

As a whole, these findings indicate both *highly statistically significant* and *statistically significant increases* cognitive complexity from a <1 min treatment. The PostD, PostS, PostR, and PostP studies substantially differ from the PreD, PreS, PreR, and PreP studies, respectively. We can conclude that:

1. people trained in Distinction-making will have more detailed and specific thoughts, whereas;
2. people trained in Systems-organizing will create more hierarchical structures and scale their thoughts up and down past the visual/conceptual question;
3. people trained in Relationship building will create and identify more and better interrelationships, and;
4. people trained in seeing Perspectives will see the stimulus from multiple points of view.

The implications this research has on metacognition and its relationship to cognitive complexity are substantial, especially when considering the very short and relatively shallow treatment. With a more substantive treatment, such as 1 h or 1 semester training (i.e., the training norm) the effects may be truly transformative. Future studies might vary the depth and length of the treatment or focus the treatment on sub-aspects of the D, S, R, or P patterns or elements, or on combinations thereof. In addition, similar studies could be undertaken in more specialized domains with demographically or psychographically specialized samples, rather than the general sample and content domain chosen for this study for the purpose of generalizability.

The plethora of different analyses of these data in this collection of studies clearly demonstrate that a short treatment of D, S, R, or P has both *highly statistically significant* and *statistically significant* effect on a participant's cognitive *and* conceptual complexity. The "Fish Tank" experiments show that less than one minute of reading bulleted text can change a person's thinking *significantly*. Further, the Fish Tank experiments show that the awareness of the universal patterns of mind (DSRP) improves the quality and quantity of a person's observations.

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

Abbreviations

The following abbreviations are used in this manuscript:

DSRP	DSRP Theory (Distinctions, Systems, Relationships, Perspectives)
D	identity–other Distinctions
S	part–whole Systems
R	action–reaction Relationships
P	point-view Perspectives
STMI	Systems Thinking and Metacognition Inventory
IQR	Interquartile Range
GLMM	Generalized Linear Mixed Modeling
RDS	Relate-Distinguish-Systematize Jig

Notes

1 We would use the words "gap in the research here" but a gap implies something missing between two existing things. Whereas a dearth is a scarcity or lack of something altogether.

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

3 In other words, Black, Hispanic and Native Americans statistically tend to be disadvantaged when it comes to educational attainment and get lower test scores overall than White or Asians Americans [161,162].

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