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On the Meanings of Self-Regulation: Digital Humanities in Service of Conceptual Clarity

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Self-regulation is of interest both to psychologists and to teachers. But what the word means is unclear. To define it precisely, two studies examined the American Psychological Association's system of controlled vocabulary—specifically, the 447 associated terms it presents—and used techniques from the Digital Humanities to identify 88 closely related concepts and six broad conceptual clusters. The resulting analyses show how similar ideas are interrelated: self-control, self-management, self-observation, learning, social behavior, and the personality constructs related to self-monitoring. A full-color network map locates these concepts and clusters relative to each other. It also highlights some of the interests of different audiences, which can be described heuristically using two axes that have been labeled *abstract versus practical* and *self-oriented versus other-oriented*.

. . . in psychology there are experimental methods *and conceptual confusion*. . . The existence of the experimental method makes us think we have the means of solving the problems that trouble us; though problem and method pass one another by.

Ludwig Wittgenstein (1953/2009),
Philosophy of Psychology—A Fragment, §371

Psychologists work with concepts that are often somewhat familiar to everybody—but the everyday terms are used in fuzzy and sloppy ways and carry lots of connotational baggage. Jargon is used because it is precise. New terms can be defined carefully, so that writers and informed readers share an exact understanding of what is meant.

Roy Baumeister, quoted in “Words and Sorcery”
(p. 198), by Oxenham and Sutton (2015)

At the time of writing, both Burman and Shanker were jointly affiliated with The MEHRIT Centre, a nonprofit spin-off of the Milton and Ethel Harris Research Initiative at York University. Burman is now instead jointly affiliated with York University, Canada, and the University of Geneva (FPSE), Switzerland.

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There is a problem with self-regulation. The concept is extremely popular, but its definition is ambiguous: “management of the self, *by* the self” (e.g., Hammerberg, 2004, p. 366; Martin & McLellan, 2013, p. 135); “control *over* the self, *by* the self” (Audiffren & André, in press, p. 2; Baumeister & Exline, 2000, p. 30; Carlson, 2009, p. 88; Converse, Piccone, & Tocci, 2014, p. 65; Farley & Kim-Spoon, 2014, p. 434; Fischer, Greitemeyer, & Frey, 2007, p. 1309; Muraven & Baumeister, 2000, p. 247); and—self-referentially—“regulation of the self, *by* the self” (Bown & White, 2010, p. 434; Cukrowicz & Joiner, 2005, p. 160; Duckworth, 2011, p. 2639; Effeney, Carroll, & Bahr, 2013, p. 774; Flouri, Midouhas, & Joshi, 2014, p. 1044; Forgas, Baumeister, & Tice,

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2009, p. 4; Gawrilow et al., 2014, p. 806; Hofer, Busch, & Kärtner, 2011, p. 211; McDermott & Fox, 2010, p. 91; McKee, Ntoumanis, & Taylor, 2014, p. 300; Sheldon, Joiner, Pettit, & Williams, 2003, p. 305; punctuation, emphasis, and cited provenance varies). The result is that different interpretations are being reflected in the scholarly literature (cf. Dean, 1995, p. 563). Self-regulation, in other words, has *multiple discursive meanings* that are being acted upon as if they each were its sole scientific meaning (see also Boekaerts & Cascallar, 2006).

This is a challenge for psychological scientists because experimental findings can conflict needlessly as a result of clashing assumptions in setup, interpretation, and intent. (As is now well understood by philosophers of science, reported results are underdetermined by observation: they are “theory-laden” [following Hanson, 1958, pp. 2, 19; also Kuhn, 1962/2012]). The ambiguity is also a major hurdle for school teachers, especially those who want to apply ideas about self-regulation to improve their students’ classroom experience, learning outcomes, and general well-being.

In short, the problem is this: in translating these findings across contexts for both specialist and public consumption, different implicit and unarticulated meta-theories will cause conflicts in interpreting the resulting *from knowing to doing* recommendations. But this then led us to wonder: *What else might be obscured by the lack of conceptual clarity?* (What might we be better able to understand—scientists and practitioners alike—if the meanings inherent to this important subject could be made more precise?)

To pursue this line of questioning specifically, we have taken advantage of the recent emergence of the Digital Humanities as a mode of scientific enquiry in psychology (e.g., Green, Feinerer, & Burman, 2013, 2014; Greenfield, 2013). Indeed, here, we have adopted some of its methodological strategies to parse the definitions informing the psychological study of self-regulation: we have taken advantage of a complete and agnostic third-party survey of the discipline’s territories (the American Psychological Association’s [APA] article-indexing program for PsycINFO), and used the resulting analyses to differentiate and focus on the different sets of meanings that shape psychologists’ interpretations of observed phenomena. To make these meanings easier to see in relation to each other, we then also produced a relational network map (cf. Green, Feinerer, & Burman, 2015a, 2015b; Pettit, Serykh, & Green, 2015). This clearer perspective is intended to guide future research by signposting both the real and the rhetorical features of the discipline, while

at the same time making the underlying concepts easier to understand, communicate, and apply.

Two studies are presented, examining the dictionary meanings of self-regulation as the concept is defined in psychology. The first study used the controlled vocabulary implemented in PsycINFO to identify the *dominant meanings* that influence American psychologists’ perceptions. The second study then illustrates these findings—and locates the boundaries separating territories of potential conflict and collaboration (following Burman, 2009)—by showing how the dominant definitions cluster with lesser terms to form larger theory-laden meaning groups.

Our intent, broadly speaking, is to show the plurality of technical meanings that influence audiences’ various understandings of self-regulation. But the resulting illustration is also akin to a web of belief (Quine & Ullian, 1970/1978). As a consequence, we are able not only to provide an overview of what it is *possible to say* about self-regulation in psychology, but also how different *partial* interpretations can conflict as strongly held visions of the same fundamental phenomena. In this, however, the extant conceptual imprecision represents not only a key translational issue: the problem is not just one of clearly communicating results so that they can be put into practice, but also one of clarifying the entirety of the set of potentially conflicting understandings that enable the pursuit of new discoveries as “thinkable things” (Lewis, 1943, pp. 238, 239, 240). Indeed, this is necessary if applications of the relevant concepts—otherwise indeterminate psychological and educational *gavagai* (Quine, 1960)—are to be accepted by skeptics as more than “just another educational fad” (Soupcoff, 2012, p. A14).

Study 1: Identifying the Dominant Senses of Self-Regulation

The semantics of psychological science—what the words used by psychologists mean to other psychologists—are governed by the *APA Dictionary* (VandenBos, 2006, 2009) and the *APA Thesaurus* (Tuleya, 2007). These sources provide the definitions that underpin the discipline. In this sense, they precede the understandings of those who would apply the insights arising from reported findings. Yet they are also the authority to which scientists and practitioners can turn in clarifying an ambiguous concept. To enable researchers to then find the relevant literature pertaining to the specific

uses intended, stripped-down versions of the dictionaries have been integrated into PsycINFO (see “An Index Term,” 2012; “Building Tools,” 2012). The meanings they contain are accessible using a tool built directly into the APA’s PsycNET interface: Term Finder.

PsycNET’s Term Finder works just like a regular dictionary, except that its definitions are not provided in full sentence form (cf. “of the self, by the self”). Instead, meanings are implied by nested lists of related words: lists with entries defined by lists, which point to still more lists.

Here, we have captured the relations defined by these lists to examine what their relatedness implies about the meanings of the interconnected concepts. In other words, we have constructed a network: we have mapped self-regulation’s definitional web. To present the results in a way that could then be used as an intuition pump—a tool for thought to inform new science, new practice, and new policy (Dennett, 2013)—we have also used a free and open-source visualization package to illustrate the data: Gephi (Bastian, Heymann, & Jacomy, 2009).

Gephi’s purpose is to convert relational data into network maps. It can also be used to conduct analyses that describe these maps in quantitative terms. In our first study, however, we were not interested so much in *describing* the contents of the dictionary as we were concerned with *identifying the most influential meanings* that the APA provides for self-regulation. As a result, what follows diverges somewhat from standard network analyses: rather than starting with an illustration of everything and its interconnections, we instead implemented a blind link analysis to deduce the source concept’s primary meanings. These then provided a set of foci that we used in interpreting the subsequent visualization. And they allowed us to go beyond the standard discussions of network analyses (e.g., regarding topographical centrality), so we could stay focussed on our problem: presenting a clearer definition of self-regulation. (To jump ahead to the two new definitions we have abstracted from our analyses, see the large blocks of italicized text at the end of the article.)

Method

Each entry in the controlled vocabulary is linked-to in Term Finder. We captured these links by defining them using two columns in a spreadsheet program: the entry itself was noted in a column labeled *source* and each of the definition-terms was noted in a new row of a column labeled *target*.

Every unique entry in either column thus became interpretable by the software as a node in our network, and the relations defined along the rows across the columns became the network’s connecting edges. (For a clear but technical discussion of how such an approach can be used to identify communities from the interconnections thus defined, see Girvan & Newman, 2002.)

We started with the Self Regulation entry, which is the term in the APA’s controlled vocabulary that most closely matches our chosen concept of self-regulation. (To make it clear when we are referring to a controlled term, these will be referred to in caps with no hyphens.) This process of defining edges using dictionary entries as nodes was then repeated for all listed terms, down through three levels of definitions, to capture all of the terms that are relatable to self-regulation (and without regard for our own particular subject-related research interests).

For those who wish to replicate the work, the procedure was as follows: (0) identify a term in the controlled vocabulary that describes the concept you seek to define (i.e., for self-regulation, we chose Self Regulation) and record it in the source column of the spreadsheet. With the term identified, then: (1) capture the source’s relations to all of its associated terms—which Term Finder provides under headings titled “used for,” “broader,” “narrower,” and “related”—by recording each of them in the target column in a new row while at the same time carrying over the source so that every row is populated by two entries; (2) for each of the associated terms, repeat these first steps to capture what we will call their *second-order definitions* by setting the associated term as the new source and each second-order definition as a target in its own row; (3) for each of those second-order definitions, capture what we will call their *third-order anchors* by again noting sources and targets in new rows; and (4) remove duplicates, so that repeated mentions of the same relations are not misinterpreted by the software as being quantitatively meaningful.

The resulting list will contain entries that refer to each other, and it is this cross-referencing that is most important in terms of defining the network topography: two sources that refer to the same target are related by their shared reference to it, and all of their associated terms are also thus related to each other indirectly by that connection. We then exported these data from the spreadsheet and imported them into the Data Laboratory workspace in Gephi. To precisely characterize the influence of each definition in the overall network, and thereby

identify the primary meanings of self-regulation, we used the tools provided in the Statistics panel to calculate each node's PageRank (Brin & Page, 1998).

PageRank provides the mathematical basis for Google's search engine. It is their principal method of determining the relevance of any one document in a large collection of mutually interlinking texts (e.g., the pages of the World Wide Web). However, we used it to provide a rank ordering of our identified terms and quantify the distance between them.

The system works by providing a measure of connectedness, reflecting the observation that highly cited sources contribute more to the perceived meaning of a collection than less well-known texts. (More correctly, however, PageRank is a probabilistic model of findability if a searcher were to randomly land on any one node in the network and then seek to find another node solely by traveling the available links: a greater number of inbound links implies greater relevance because those nodes are more findable from more places in the network.) Following this approach, individual nodes can then be ranked according to how they are linked-to by all of the other nodes: a finite amount of findability (100%) is apportioned throughout the entire network, with more findable nodes ranking more highly.

The standard empirical article would at this point present inferential statistics as results. That is not necessary here: our sampling of the relevant contents of the dictionary is complete. However, the PageRank itself is indeed a calculated probabilistic metric. For this reason, the *z* score is a convenient tool for reporting conceptually significant differences in findability. This also provides the means to derive the standard measures with which psychologists are familiar, and thus the *z* score offers a useful rhetorical device for explaining our results (viz. using *z*-critical values, for given α , thereby providing a nonparametric equivalent to the more common *p* values). In addition, the results are then comparable between different analyses of different terms of interest because the scaling will always be relative to the topology of each term's defining network: when the total amount of a given network's findability is always only 100%, comparing the primary meanings of concepts with different networks is greatly simplified.

Results

According to the APA's controlled vocabulary, the meaning of the Self Regulation index term is

interpretable through the definitions of seven related terms: Agency, Emotional Regulation (used for affect regulation), Self Control (used for will-power), Self Management, Self Monitoring (used for self observation), the parenthetically named Self Monitoring (Personality), and Self Regulated Learning. Each of these is then interpretable through their own sets of related terms, expanding the total number of implicated definitions to 49. And the meanings of this second-order set can be anchored, topographically, such that the total number of terms considered is 447—all of which are distinct and locatable. (This anchoring is crucial for the method of visualizing meanings used in Study 2: terms linked-to by other relevant definitions will be drawn in closer to each other by the layout algorithm, while terms not linked-to will be pushed outward to the periphery, preserving topographical centrality and proximity as simple heuristics in interpreting meanings.)

Together, the three levels define all aspects of everything connected in the *APA Dictionary* to self-regulation as a scientific concept. If something has not been captured by this method, it is simply because the term has not (yet) been defined in that way by the APA.

The PageRank analysis produces a rank ordering of connectedness with a very large number of low-relevance nodes and a very small number of high-relevance nodes. These results can be seen directly for top terms in Table 1, while the histogram in Figure 1 simplifies all of the data and shows their skew. What this all means, though, is fairly simple: if a randomly walking searcher were to start at a series of different locations in the network, and follow different paths while exploring the conceptual landscape, then they would likely pass in predictable proportions through the same small number of highly connected points.

That said, however, this analysis also shows something surprising about the meaning of self-regulation: the most highly connected term in the network is not Self Regulation (with a *z* score of 6.4)—as we would have expected, given that this is where we started—but rather Self Control (11.9). Indeed, as we can see from the *z* scores listed in Table 1, this dominant definition is almost twice as findable as the expected term ($\alpha < .001$).

This surprising result is a function of the interrelatedness of terms in the dictionary: more terms associated with self-regulation point to Self Control as one of their meanings than to anything else. That said, however, Self Control (11.9) is not alone in outranking Self Regulation (6.4) in findability. It is

Table 1
Self-Regulation Terms With Unfiltered z Scores > 0.5 (i.e., Top 44 of 447 Possible)

Controlled term	Study 1		Study 2	
	PageRank (unfiltered)	z score (unfiltered)	Cluster	Other boundaries
Self Control	1.12	11.86	Self Control	
Self Monitoring	0.78	7.43	Self Monitoring/Self Management	
Self Regulation	0.70	6.38	N/A	Self Monitoring/Self Management Self Control
Self Management	0.68	6.03	Self Monitoring/Self Management	
Emotional Regulation	0.67	6.00	Self Control	
Self Monitoring (Personality)	0.54	4.21	Self Monitoring (Personality)	
Emotional Control	0.48	3.34	Self Control	
Self Evaluation	0.47	3.27	Self Monitoring/Self Management	
Self Perception	0.40	2.41	Self Monitoring (Personality)	
Agency	0.40	2.35	Agency/Self Determination/ Locus of Control/Helplessness	
Self Determination	0.39	2.28	Agency/Self Determination/ Locus of Control/Helplessness	
Behavior Modification	0.39	2.27	Self Monitoring/Self Management	
Internal External Locus of Control	0.37	1.93	Agency/Self Determination/ Locus of Control/Helplessness	Self Control
Helplessness	0.35	1.63	Agency/Self Determination/ Locus of Control/Helplessness	
Self Regulated Learning	0.34	1.54	Self Control	Learning/Learning Strategies
Personality Traits	0.34	1.48	Self Monitoring (Personality)	
Affect Regulation [not shown]	0.33	1.46	Self Control	Indexed as Emotional Regulation (z = 6.00)
Reflectiveness	0.32	1.29	Self Monitoring (Personality)	
Self Report	0.32	1.25	Self Monitoring/Self Management	
Anger Control	0.32	1.22	Self Monitoring/Self Management	Self Control
Self Help Techniques	0.31	1.20	Self Monitoring/Self Management	
Impulse Control Disorders	0.31	1.15	Self Control	Social Behavior
Personality	0.30	1.08	Self Monitoring (Personality)	
Cognitive Therapy	0.30	1.08	Self Monitoring/Self Management	
Personality Processes	0.30	1.04	Self Monitoring (Personality)	Social Behavior Self Monitoring/Self Management
Self Criticism	0.30	1.03	Self Monitoring (Personality)	Self Monitoring/Self Management
Introspection	0.30	0.97	Self Monitoring (Personality)	
Impulsiveness	0.29	0.89	Self Control	Social Behavior
Behavioral Disinhibition	0.29	0.87	Self Control	Social Behavior
Volition	0.29	0.87	Agency/Self Determination/ Locus of Control/Helplessness	
Interpersonal Control	0.29	0.85	Agency/Self Determination/ Locus of Control/Helplessness	
Social Comparison	0.29	0.82	Self Monitoring/Self Management	
Social Perception	0.29	0.82	Self Monitoring/Self Management	
Self Efficacy	0.28	0.75	Agency/Self Determination/ Locus of Control/Helplessness	Self Control Self Monitoring/Self Management
Cognitive Techniques	0.28	0.69	Self Monitoring/Self Management	
Learning	0.27	0.66	Learning/Learning Strategies	
Empowerment	0.27	0.65	Agency/Self Determination/ Locus of Control/Helplessness	
Perfectionism	0.27	0.62	Self Monitoring (Personality)	

Table 1
Continued

Controlled term	Study 1		Study 2	
	PageRank (unfiltered)	z score (unfiltered)	Cluster	Other boundaries
Temptation [not shown]	0.27	0.61	Agency/Self Determination/ Locus of Control/Helplessness	Near to Individuality/Independence (Personality)
Control (Self) [not shown]	0.27	0.61	Self Control	Indexed as Self Control (z = 11.86)
Willpower [not shown]	0.27	0.61	Self Control	Indexed as Self Control (z = 11.86)
Learning Strategies	0.27	0.59	Learning/Learning Strategies	
Self Instructional Training	0.27	0.58	Self Monitoring/Self Management	
Psychotherapeutic Techniques	0.26	0.52	Self Monitoring/Self Management	
Reinforcement	0.26	0.50	Learning/Learning Strategies	Self Monitoring/Self Management

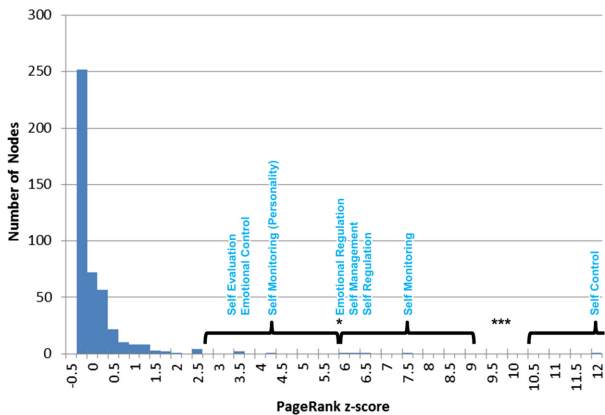


Figure 1. Scaled comparison of the different “findabilities” in the unfiltered network defining self-regulation (Study 1). It is clear that some terms are significantly more findable (more relevant) than others. Top terms are labeled directly in the histogram; asterisks indicate the degree of difference, in terms of scaled distance, from the central term.

also joined by Self Monitoring (7.4). Yet while this is itself significantly different from Self Control ($\alpha < .001$), it is not so from Self Regulation ($\alpha > .05$). In fact, in examining the z scores we see that the four top terms defining self-regulation after Self Control are all approximately equivalent in their influence: Self Monitoring (7.4), Self Regulation (6.4), Self Management (6.0), and Emotional Regulation (6.0) are all significantly different from the next highest ranked term—Self Monitoring (Personality), with a z score of 4.2—but they are not significantly different from each other ($\alpha > .05$). This blurring of secondary meanings has important implications, which we will discuss and develop throughout the remainder of this article.

Discussion

The sum of all of the PageRanks for all 447 nodes is 1. In other words, tautologically, if a searcher starts at all nodes, then the probability of their finding any node is 100%. (The whole, in this case, is identical with the sum of its parts.) The challenge is then to reduce the number of parts to a meaningful representative sample: which of the 447 nodes are *most relevant* to our problem? (What concepts would need to be included in a clearer definition?)

If Google’s method—calculating findability—is acceptable as a means of determining relevance (in more than a colloquial sense), then focusing on the highest ranking nodes can provide an assessment of the most relevant contributors to the meaning of the overall network. From this perspective, then, the *primary* meaning of self-regulation is therefore that of self-control: if this were a Google search, then Self Control is the node in this network that would receive the most referred traffic (i.e., nearly double that of the next most relevant node). Yet the next four terms—the network’s secondary meanings—would *collectively* receive more traffic still. Therefore, the meaning of this network as a whole cannot be so simply defined: not only is the present meaning of self-regulation ambiguous, but *so is what it is possible to meaningfully say about self-regulation*.

That said, however, we cannot end there. It is not clear from the PageRank ordering alone whether what we seek is most appropriately attached to the individual definitions, or if they ought to be treated in clusters that collect together groups of definitions to form higher order concepts.

That will be examined in Study 2, with a view to ultimately providing a new—clearer—definition for self-regulation.

Conclusion From Study 1

Noting the relations between the terms defined in the APA's controlled vocabulary enabled us to delve more deeply into the various meanings of a source term: Self Regulation. Rather than having to rely on a list of seven potentially ambiguous dictionary-provided definitions, however, we were able to use how these terms are themselves defined by the APA to access hundreds of related interpretations. These were then ranked using a standard algorithm (Google's PageRank), providing an ordered list of the most influential associated meanings.

In other words, by taking advantage of techniques more often associated with search and information retrieval, we have been able to treat the APA's controlled vocabulary as a directed network. From this perspective, definitions point outward from a source term and inward toward their associated target definitions (i.e., the direction from source to target is what operationalizes the association and expresses one term's relatedness to the other). Analyzing the connectedness of these links then provided us with a quantitative estimation of the influence of the most influential meanings used by the discipline's dominant professional association in parsing and interpreting the science of self-regulation.

The primary result was surprising, but it is also consistent with the public's recent embracing of popular books on this topic: the public understanding of self-regulation does indeed seem to be that of willpower (Baumeister & Tierney, 2012; McGonigal, 2012), focus (Goleman, 2013), and grit (Duckworth, in press; Tough, 2012). These are all stories of self-control (see also Mischel, 2014). Yet this does not seem to us to be as useful—to teachers—as some of the alternative meanings that are obscured by the influence of the self-control narrative, such as Self Monitoring, Self Management, and Emotional Regulation. (Briefly: If it is possible for a child to achieve the goal of greater self-control by learning and practicing skills related to self-observation and self-management, then this suggests a different approach to controlling disruptive classroom behavior than that typically taken today.) The next logical step, then, is to adopt a broader perspective and see if the view is different; to expand from the consideration of influential single terms to an

examination of the broader discourses to which they contribute.

Study 2: The Discourses of Self-Regulation

The standard approach in network analysis is to identify and then examine communities of similarity (e.g., Green et al., 2015a, 2015b). This is often given a sociological cast (e.g., Pettit et al., 2015). Yet our data have been derived from the APA's controlled vocabulary rather than from how those meanings have been used by the authors who collectively make up the discipline: our study is one of *semantics*, not *pragmatics*. (Due to limitations of space, and the added complexity of the methods required to extract these additional data from PsycINFO, we will save that more explicitly social examination for a follow-up study.) Here, therefore, we want simply to define the discourses *in which it is possible* for communities of experts to engage. That will then provide a more solid foundation upon which to build in future work.

Our approach in Study 2 was to pursue the goal identified in Study 1: to reduce the number of parts, while at the same time preserving what matters most of the whole. We did this by identifying clusters of meanings, using Gephi's modularity tool (see Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). Then, because the probability of finding a cluster during a search can be understood as being a function of the probability of finding its members, we needed only to sum together the findabilities of the cluster members using the PageRanks calculated in Study 1. That then provided an assessment of the influence of each of the clusters on the overall meaning of self-regulation as a scientific concept.

Study 1 examined relations between terms to determine findability (a formal approach for defining relevance), but it did not visualize the results. Study 2 therefore provides the visualization expected of network analysis, but then we leverage the results from Study 1 to extend its implications still further.

Method

Picking up directly from Study 1, in Gephi, we switched from the Data Laboratory workspace to the Overview workspace. We then used the Force Atlas 2 layout algorithm to organize the nodes according to the interrelations defined by their edges (see Jacomy, Venturini, Heymann, & Bastian, 2014). This provided an unfiltered relational cloud.

But it also included many definitions that are irrelevant to our intent: we wanted to focus solely on those terms that matter most to self-regulation as a scientific concept, while ignoring those that do not. (This filtering required a further step, taken after others that required the raw data.)

With the data mapped, we used the modularity tool to identify clusters of meaning. So that the resulting analysis would reflect the interconnectedness in the dictionary, we turned on the *use edge weights* option. We also used the default resolution of 1. The resulting modularity of the clusters was calculated to be 0.550. Repeated analyses changed the boundaries slightly, but the affected nodes were small and the resulting differences minor. (Still, these minor differences are accommodated below in the discussion of boundary objects.)

The modularity analysis' groupings informed our group-findability calculations: the PageRank results from Study 1 were summed according to their calculated group membership. These calculations are inferential (they are based on both the PageRanks and the modularity analysis), but the network itself is not. That is a key point: the network is an illustration of the relations defined in the controlled vocabulary. The semantic map is therefore itself a description, not an inference.

Using the in-degree filter, we hid all nodes with fewer than two inward definition-seeking links. ("In-degree" is a more local measure than PageRank [discussed by Fortunato, Boguñá, Flammini, & Menczer, 2008].) This then filtered out all of the least individually relevant nodes of the network, and reduced the number shown in the visualization from 447 to the 88 most conceptually significant terms. However, we preserved the original unfiltered layout provided by the algorithm: the effect of these less meaningful nodes, in the visualization, is to pull unrelated terms further apart while allowing connected terms to remain close to each other. That distance, in the visualization, is intuitively valuable: nodes that are closer together are typically also more closely related.

Results

Gephi's modularity analysis identified six clusters at the default resolution. To simplify the resulting map, the members of each cluster have been color-coded (see Figure 2, with legend and associated data in Table 2). To simplify naming, they have also been labeled according to their dominant nodes (using the *z* scores calculated in Study 1). Finally, to distinguish between node names and

cluster names, we will use **bold text** in referring to the clusters.

Listing the clusters clockwise, starting from the top-right, provides the following territories in our map of the semantics of self-regulation:

1. **Learning/Learning Strategies**
2. **Self-Monitoring/Self Management** (including Self Evaluation and Behavior Modification)
3. **Agency/Self Determination/Internal External Locus of Control/Helplessness**
4. **Self-Control** (including Emotional Regulation and Emotional Control)
5. **Social Behavior**
6. **Self-Monitoring (Personality)** (including Self Perception, Personality Traits, Reflectiveness, and Personality)

To make the map easier to read, we have also added some boundaries. These have been placed at the approximate midpoints between the groups, where the clusters blur into each other. Orphans that have been separated from their cluster—or that sit on boundaries—are contained in circles to separate and mark them out specifically.

We think that this map provides a reasonable parsing of the conceptual meanings associated with self-regulation as a scientific concept. The large clusters include enough members to afford a useful simplification, the vertices separating them are intuitively sensible, and the overall organization makes sense: **Self Monitoring (Personality)** on the left transitions through both **Self Monitoring/Self Management** and **Self Control** (via **Social Behavior**) in the center before arriving at **Agency/Self Determination/Locus of Control/Helplessness** on the lower-right. And the Self-Regulated Learning node is located, as expected, with the **Learning/Learning Strategies** cluster.

From these results, and taking advantage of our earlier calculation of each node's PageRank (in Study 1), it was a simple matter to calculate the findability of each cluster. Table 2 summarizes these data. The key finding is given by the column labeled Percentage of Map (filtered).

Self Monitoring/Self Management is thus shown to account for 27.3% of the meaning of self-regulation and **Self Monitoring (Personality)** for slightly less with 21.8%. **Learning/Learning Strategies** is also better represented than expected with 17.7%, while **Self Control**—surprisingly—accounts for only 16.5%. **Agency/Self Determination/Locus of Control/Helplessness** accounts for 15.9%, and **Social Behavior** for barely 1% (although it is worth

Mapping the Discourses of Self-Regulation

Modularity Analysis of the Filtered Network, Defined by the APA's Controlled Vocabulary, Indicates Six Interpretive Clusters. These are Named for Their Most Influential Individual Node. Approximate Boundaries are Provided to Aid Interpretation

The Full Unfiltered Map Includes 447 Nodes and 628 Edges. After Excluding All Nodes With Fewer than two in-Bound Links, 88 Nodes and 247 Edges Remain Visible. The Unfiltered Geometry is Preserved

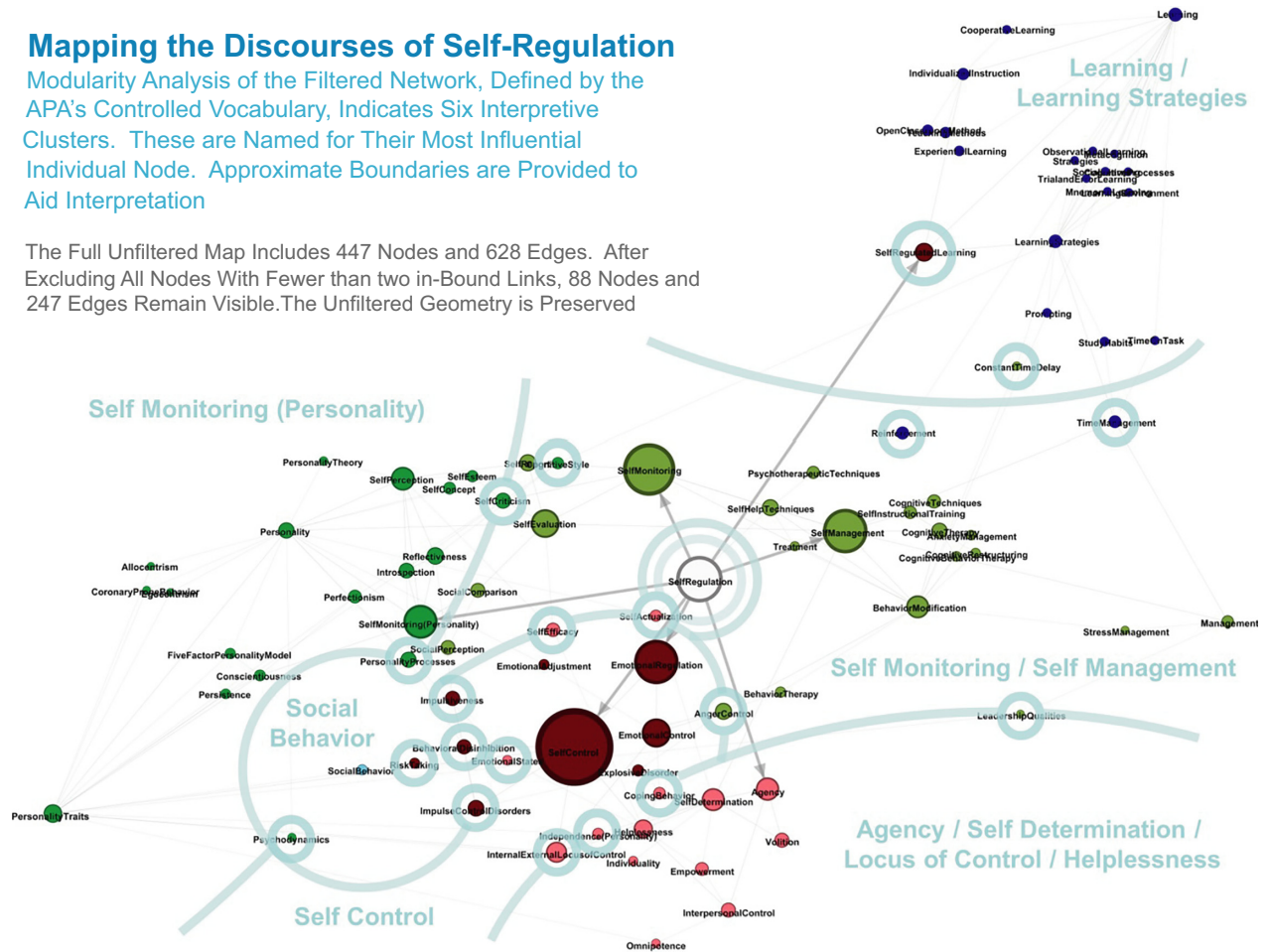


Figure 2. Mapping the discourses of self-regulation.

Table 2
Cluster Analysis as Map Legend (Color-Coded)

Modularity class	Color code on map	Name	Sum of PageRanks (unfiltered)	Percentage of map (filtered) (%)	Rank	Number of nodes	Density per term on map
-1	White	Self Regulation	N/A	N/A		1	N/A
0	Maroon	Self Control	4.21	16.48	4	10	1.65
1	Pink	Agency/Self Determination/ Locus of Control/Helplessness	4.06	15.89	5	14	1.13
2	Army Green	Self Monitoring/Self Management	6.97	27.29	1	22	1.24
3	Green	Self Monitoring (Personality)	5.56	21.77	2	20	1.09
4	Light Blue	Social Behavior	0.23	0.92	6	1	0.92
5	Dark Blue	Learning/Learning Strategies	4.51	17.65	3	20	0.88

noting that *the social* is implicated in terms grouped with other clusters, such as the nearby nodes Social Perception and Social Comparison).

To help readers focus on the most significant nodes, in considering the individual terms sepa-

rately from the clusters to which they belong, these have each been sized according to their calculated PageRank: the larger the node, the more findable it is. The cluster-findability scores can then be understood to be a sum of the areas of the nodes in that

color code (although similarities between colors are not themselves meaningful).

Finally, it is worth noting that we have expanded the boundary in the visualization for the **Social Behavior** cluster to overlap more strongly with its neighbors than we initially thought to do. This is to reflect the recognized intersection between Social and Personality, as subdisciplinary domains of psychology, and also our pragmatic understanding of the nearby concepts. (For example: risk taking is more likely among teens when they are in a peer group, but less likely when with their parents [Farley & Kim-Spoon, 2014; Rai et al., 2003].) Indeed, it seems more theoretically appropriate to label this group “co-regulation.” Yet this would require its own argument (e.g., Hadwin & Oshige, 2011; Volet, Summers, & Thurman, 2009). Thus, to keep things simple—even though the resulting labeling is not as scientifically useful as we might like—we have kept to the labels provided by the z scores.

Discussion

The use of Gephi’s in-degree filter is crucial for simplifying the visualization of the data generated by Study 1. Only those definitions with more than one referring entry in the controlled vocabulary have been included in the map (Figure 2). This reduced the number of visible nodes by more than 80%, and yet only reduced the number of visible edges by 60%. In other words, what we might call the *information density* of the remaining mapped nodes has been doubled by the filter’s use: we have retained only 20% of the terms offered by the dictionary (nodes) but accounted for 40% of its provided definitions (edges).

Delving into this more deeply, it is clear that the filter eliminated a large number of definitions from the controlled vocabulary that are not relatable to self-regulation in a scientifically meaningful way. For example: the **Learning/Learning Strategies** cluster of self-regulation is defined relevantly in the map as being concerned with Meta Cognition, Learning Environment, and Experiential Learning. Yet, without the filter, it was also defined irrelevantly as involving Rat Learning, Cat Learning, and Machine Learning. (These are specialist subject areas that may indeed involve discussions of self-regulation, but then—because articles are described with more than one index term from the controlled vocabulary—those specific pragmatic uses would be captured by other relevant terms.) Similarly, relevant traits associated with **Self Monitoring**

(**Personality**) include Persistence and Conscientiousness, while others like Masculinity and Machiavellianism are irrelevant. (Thus, also with **Social Behavior**, Social Media is filtered out.) These irrelevant meanings are not shown on the map, and their omission represents an improvement in signal quality.

As in Study 1, a primary meaning has been identified (see Table 2). Yet this is not as expected: the dominant concept, after the cluster analysis, is **Self Monitoring/Self Management**. Indeed, between this and **Self Monitoring (Personality)**, nearly half of the map can be accounted for (49.1%). The primary meaning expected from the results of Study 1—**Self Control**—ranks fourth between **Learning/Learning Strategies** and **Agency/Self Determination/Locus of Control/Helplessness**. This apparent contradiction between studies is peculiar: *How could one term from the controlled vocabulary account for so much of the dictionary meaning of our target term when the broader concept it supposedly represents accounts for so little?*

Conclusion From Study 2

In this second study we have been able to go beyond the consideration of individual terms to examine what large groupings of relevant terms contribute to self-regulation’s conceptual topography. This then affords the basis for a much more precise definition of the term than is presently accepted, and requires only a little more space: *Self-regulation involves the monitoring and management of the self, by the self, so that behavior can be appropriately controlled—especially in learning situations. Differences in personality traits are implicated, as are differences in individual agency (or, more popularly, in willpower). But self-monitoring dominates: the control of the self is preceded by observations of the self. There is also a social component, but its effects are typically captured by other means.*

This reflects the most relevant majority of what it is possible to say about self-regulation, according to the APA’s definition of the related terms. Yet it also reflects the ambiguity in the meaning of underlying concepts—especially “self” (cf. Martin & McLellan, 2013, p. 135). Still, though, because it is becoming increasingly evident that it is inappropriate to treat such phenomena as being wholly innate (as if there were a gene for willpower), this definition could be pushed further so that the language is more consistent with more recent and emerging developmental, dynamic, epigenetic, and systemic perspectives. This would represent an extension of

the concepts reviewed, however, because those terms are not reflected in the map; it requires a meta-theoretical rejection of a nativist theory-laden view of self-control in considering self-regulation (see the next large block of italicized text below).

General Discussion of Both Studies, Presenting a New Definition

From 447 related concepts extracted from the APA's controlled vocabulary, we have identified 88 relevant variations: the dimensions of self-regulation, according to how the discipline's dominant professional association defines the associated terms. We then reduced this set to the six broad conceptual meanings that organize all of the implicated terms. In other words, we have confirmed that the meaning of self-regulation is ambiguous, but in formalizing its discourses we now also aim to make new progress simpler and easier to achieve (following Burman, 2009).

Beyond the six meanings, there seem also to be some broad axes at work in organizing the map: left to right from **Self Monitoring (Personality)** to **Self Monitoring/Self Management** decomposes almost along abstract-applied lines, while top to bottom (or, perhaps seen more easily in the mind's eye, far to close) from **Learning/Learning Strategies** to **Self Control** decomposes as other-oriented versus self-oriented (with an embedding in social interaction at **Social Behavior**). From this perspective, the central concept that we sought to define in the first place—Self Regulation—is shown to be at the middle of it all: everything to everyone, and thus not very helpful when considered on its own.

Implications for Knowledge Translation

These broad axes give us the opportunity to frame contributions in a new way. We can even attribute ideal professional personae to the six meanings of self-regulation, which may then help scholars in their attempts to orient to the different audiences that can be understood to adopt these conceptual selves as norms (cf. Morawski, 2007). Thus, for example, we can suggest that those interested in **Learning/Learning Strategies** (e.g., teachers) are likely to seem extremely other-oriented and extremely practical simply by virtue of their concern with the topics grouped with this cluster. By contrast, those interested in **Self Monitoring (Personality)** are likely to seem only moderately self-oriented yet extremely abstract (i.e., interested in

personality assessment). Those interested in **Agency**, extremely self-oriented and moderately practical (in the sense that their approach will typically be more abstract than what teachers are apt to ask for). **Self Control** then reflects a midpoint between the two self-oriented perspectives (which perhaps explains some of its popular success), with those interested in aspects related to **Social Behavior** seeming somewhat more abstract and somewhat less practical. This leaves **Self Monitoring/Self Management**, the primary meaning for self-regulation suggested by Study 2: ideally interested in both self-orientation and other-orientation, while tending toward the practical but still accepting of some abstractions.

Of course, the view out from inside any one cluster will be relative to its perspective. Distance on the map can thus be understood as a proxy for epistemic distance, with personal attributions in response to criticism then made somewhat more predictable: a distant other will seem either self-absorbed or a martyr, condescending or naïve, and irrelevant or missing the point. Such evaluations speak more about positionality than the content of the claims, however, and are thus to be treated gently: they are not criticisms, but opportunities for clarification and growth.

Still, the six meanings are not straightforward in their implications. They blur together. After adding topographical boundaries to simplify the resulting map, we also then identified several nodes that require special attention. We will call them "boundary objects" (following Star & Griesemer, 1989). These have implications for knowledge translation too, since they mark territories of conflicting interests (delivering on Burman, 2009; Kitto, Sargeant, Reeves, & Silver, 2012).

Boundary objects

Boundary objects can be adapted to a variety of perspectives, according to the interests of those referring to them. We have identified several candidates, and marked them on the map with a circle: Self Regulated Learning, Constant Time Delay, Reinforcement, Time Management, Leadership Qualities, Anger Control, Coping Behavior, Independence (Personality), Internal External Locus of Control, Impulse Control Disorders, Emotional States, Behavioral Inhibition, Risk Taking, Impulsiveness, Personality Processes, Self Criticism, Cognitive Style, Self Efficacy, and Self Actualization. These are all concepts that share multiple meanings, in the sense that they seem to flip back and forth

between interpretations, and thus require the most care in discussion and—especially—in translation from knowing to doing. Self Regulation itself, obviously, is one too: not only does it share boundaries with **Self Monitoring/Self Management** and **Self Control**, but it also alludes to all of the other meanings that we have mapped.

To try to accommodate the impact of these boundary objects on the meanings with which they are associated, we have recalculated the cluster-PageRanks for the map (Table 3). With one exception, very little changes in the cluster findabilities. But **Social Behavior** jumps by 300%. It is thus more than *implicated* in other topics (e.g., Social Perception and Social Comparison). Rather, it might be more accurate to say that its relevance and importance has been *obscured* by how we conceive of this material (cf. Burman, 2015; also in Hobbs & Burman, 2009).

Related to this, we are also now able to point out something curious about the language of psychology itself: when accounting for the number of nodes involved in defining each of these clusters, we see that what we have called their “information density” is lowest in **Learning/Learning Strategies** (0.9% per term) and highest in **Self Control** (1.6%–1.7% per term; compare Tables 2 and 3). This suggests that there is greater descriptive precision in the language of learning, at least when considering its connection to self-regulation, and much less precision in the language of self-control. This then perhaps also explains the latter’s apparent dominance when fewer terms are taken into account: according to Zipf’s Law, the rank order of a term is directly proportional to the frequency of its use (see Zipf, 1935). The skew toward Self Control that we identified in Study 1 could thus be illusory: a function solely of its relative imprecision, and thus also of the availability heuristic (Tversky & Kahneman, 1973).

Recognizing this—and also that it is primarily the self-control discourse driving the association with innate ability (viz. willpower, focus, grit)—we are now able to push our earlier empirically derived definition further: *Learning self-regulation involves learning how to monitor and manage one’s internal states and predispositions, so that behavior can be appropriately controlled not only in the classroom but also in any other situation where one is expected to become better educated or informed. This developing faculty is measurable using the standard tools of the study of individual differences, but especially those involved in studying personality. Not only is the Will implicated, but so too is the developmental pathway that can increase its power and effectiveness in controlling behavior. In other words: the learning of self-regulatory skills, especially those related to self-observation and self-management, has implications for how the Will manifests and is then measured (with further downstream effects). Or, rather: From skill comes capacity. There is also a social component to self-regulation, but in psychological studies its influence is most often captured indirectly by the measurement of other factors.* In short: the notion of self-regulation is much more complex than the “management,” “control,” or “regulation of the self, by the self.” Indeed, it encapsulates much of what psychological thinkers have been struggling with for the last several hundred years: all three domains of the neoclassical psyche—cognition, affect, and conation—are implicated (see Hilgard, 1980; also Berrios & Gili, 1995).

The challenge, for future research, will be to see how these in-theory dictionary-style definitions are actually used by research psychologists. (Has conceptual imprecision, and availability bias, skewed research in self-regulation away from potentially useful approaches?) But we leave that examination of use-meanings (pragmatics) for later, because there are complex methodological issues that need

Table 3

The Six Selves of Self-Regulation, With Cluster Percentages Adjusted to Account for Boundary Objects (Area-Based)

Name	Sum of PageRanks (unfiltered)	Percentage of map (filtered) (%)	Rank	Delta versus Table 2 (%)	Number of nodes	Density per term on map
Self Control	4.72	17.96	3	8.98	11.16	1.61
Agency/Self Determination/ Locus of Control/Helplessness	3.26	12.40	5	−21.94	11.84	1.05
Self Monitoring/Self Management	7.78	29.61	1	8.50	24	1.23
Self Monitoring (Personality)	4.98	18.97	2	−12.84	18.17	1.04
Social Behavior	1.00	3.81	6	316.28	3.83	0.99
Learning/Learning Strategies	4.53	17.24	4	−2.33	19	0.91

to be dealt with first. Those preliminaries are in preparation, however, as the effects of the Digital Humanities revolution continue to spread into psychology (e.g., Priva & Austerweil, 2015).

Final Concluding Thoughts

There is presently no precise, general, and widely accepted definition for self-regulation. There are many; dozens of competing perspectives with slightly different emphases. Yet any single scientific study can address only a handful. When results are communicated, authors therefore need to be clear about which of our six broad conceptual foundations their work seeks to build upon: **Learning/Learning Strategies, Self-Monitoring/Self Management, Agency/Self Determination/Locus of Control/Helplessness, Self Control, Social Behavior, or Self-Monitoring (Personality)**. These areas overlap, of course, but the boundaries between them represent areas of both future collaboration and potential misunderstanding.

It is heartening, however, that the most topographically central term in our map—apart from Self Regulation itself—is Self Actualization (a member of the **Agency** cluster, but located at the boundary between **Self Monitoring/Self Management** and **Self Control**). This is also reassuring to us personally because it is consistent with the motivation driving our translational work: we hope to foster the recognition and encouragement of *whatever it is* that makes it easier for children to achieve the goals they can learn to set for themselves (including, but not limited to, those of the classroom).

The colloquial expression for this broad goal is *autonomy*, and the associated controlled term is Independence (Personality). The formal semantic meaning of this boundary object, in relation to self-regulation, is then captured by the collection of concepts grouped under **Self Control** and **Agency/Self Determination/Locus of Control/Helplessness**. This is a direct reflection of the term's definition in the controlled vocabulary, which presents it as one of many concepts related broadly to Personality Traits (**Self Monitoring [Personality]**) and specifically to Empowerment (**Agency**), Internal External Locus of Control (**Agency**), Resistance (**Agency [not shown]**), and Self Determination (**Agency**). But that is not exactly what we mean either.

Our hope beyond identifying its centrality in the meaning of self-regulation is also to foster its development in situations and environments where **Learning/Learning Strategies** is the focus, while

also encouraging the development of affiliated skills related to **Self Monitoring/Self Management** and affiliative co-regulatory **Social Behavior**. In other words, we do not mean to encourage autonomous self-actualizing in the narrow sense; we intend it in a way that reflects facets of the entire map. And, indeed, a classroom influenced by such an approach would be a very different place: less focused on meting out rewards and punishments to control behavior, and more focused on providing co-constructive interactions and nudges that help lead the children to produce similar or better outcomes more easily and with less fuss. (For related readings, see Shanker, 2012; Shanker & Barker, in press; Sokol, Grouzet, & Müller, 2013.)

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