Title: Exploring the conceptual structure of Spanish Experimental Psychology

Running head: Conceptual structure of SEPEX

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Abstract

The recent incursion of experimental psychology into the arena of cognitive neuroscience has brought attention back to its conceptual foundations. As we embark on more multidisciplinary enterprises, some authors have called to rethink the taxonomy of psychology and cognitive neuroscience in order to build stronger theories. While some claim that, compared to other disciplines, the ontology of psychology precedes scientific work and has minimally departed from “folksy” terminology, others argue psychology’s *explanandum* confers a special status to folk insight. Here, we examine which psychological constructs are prevalent in the abstracts of five editions of the SEPEX meeting and compare them with those present in William James’ seminal Principles of Psychology. Additionally, we assess aspects where Spanish’ experimental psychology might fall behind to identify promising, relatively unexplored research avenues. Together, this initial exploration aims at characterizing the current conceptual status of Experimental Psychology in Spain. In a broader sense, we expect to raise awareness on the importance of a robust and up-to-date ontology given the increasingly multidisciplinary field in which our discipline now plays.

Keywords: ontology, theory building, conceptual structure

INTRODUCTION

More than a century ago, William James published his seminal Principles of Psychology (James, 1890). Terms such as Attention, Memory, or Thought were signaled by James as the *Scope of Psychology.* These terms, which stem from everyday language, have shaped research in Psychology since its early beginning and are widely adopted by the scientific community. It has been argued that such prominence of folk terminology in psychological research is a natural consequence of psychology's explanandum: insofar experimental psychology concerns our subjective mental experience, it will likely rely on labels we use in everyday life to describe such experiences. The mainstream approach in Psychology has been to adopt and then atomize these terms into smaller, somewhat independent, units that, in favor of a more concrete (but still mainly verbal) definition, are sometimes only loosely related to the original concept.

In recent years, criticism has arisen about the robustness of the conceptual structure of Psychology as a discipline, pointing to an overreliance on essentialist terms (Brick et al., 2021), on poorly-defined polysemic constructs (Hommel et al., 2019) or on folksy terminology (Poldrack & Yarkoni, 2016). Take, as an illustrative example, the term *memory*. *Memory* is sometimes used to refer to a trace of stored information in neurocognitive systems (e.g., "my memory of breakfast this morning") and sometimes used to refer to the whole set of processes that jointly handle storage, retention and retrieval of information. As a consequence, while there are many research groups specialized in *memory*, the breadth of techniques, methodologies and approaches used make it difficult to find overarching frameworks with sufficient explanatory power. This multiplicity of meanings can be easily found in other classic Psychological constructs such as Attention (Hommel et al., 2019) or Consciousness (Michel et al., 2019) and also in newer ones such as Prediction (Litwin & Miłkowski, 2020). Although polysemia is an ever-present feature of natural language, its preponderant presence within a scientific discipline could cause unnecessary confusion in the best case scenario and reflect poorly defined concepts in the worst one.

Relatedly, the lack of robust conceptual grounds can potentially hold back the progress and development of strong theories for any discipline (Barrett, 2017; Brick et al., 2021; Fried, 2020). We argue that a precise characterization of the conceptual structure can provide great insights into the state of the knowledge of a given field. Here, we present an initial exploration of the current ontological space of Experimental Psychology in the Spanish context. To do so, we examine the abstracts submitted across five editions, spanning ten years, of the Conference of the Spanish Society for Experimental Psychology (SEPEX), with the following goals: 1) to ascertain the degree of construct-orientedness of the society, 2) to identify the most prominent terms used in the Spanish context, 3) to assess the reliance on pre- vs. scientific terms and 4) to identify limitations of our current ontology and to hint at potential mitigation strategies to overcome them.

METHODS

Text parsing

SEPEX texts were extracted from .pdf documents containing the book of abstracts from the different editions of the conference. In order to convert abstracts into a manageable format, we performed a series of preprocessing steps. All of these steps were automated and no manual edition was involved. First, abstracts written in Spanish were translated into English using the Google translate API via the python library *googletrans*, and all non-english characters (e.g. “ñ”) were removed. Then, we used the functionalities of the Python library Natural Language Toolkit (*nktl*) to 1) tokenize (i.e. convert text to sentences) the abstracts, 2) convert the resulting sentences to words, 3) remove English “stop words”. Stop words are commonly used words (e.g. “a”, “the”, “in”, “for”) that are actively ignored when querying large sets of strings (please see https://gist.github.com/sebleier/554280 for a full list of stop words used).

Regarding William James’ texts, we tailored pre-existing code (https://github.com/poldrack/william_james) to parse an online version of James’ Principles of Psychology (available at http://psychclassics.yorku.ca/James/Principles) and transformed it to .json format for better handling.

Lexicons retrieval

Lexicons consist of a database containing a list of related terms and their definition. We took advantage of recent efforts in cognitive neuroscience to organize and structure knowledge in the field to find relevant lexicons. Concepts and Tasks lexicons were retrieved from the Cognitive Atlas (Poldrack et al., 2011). The Disorders lexicon was retrieved from the Disease Ontology database (Schriml et al., 2011). Last, the (neuro)Anatomy lexicon corresponded to the NIF-GrossAnatomy lexicon contained in the Neuroscience Information Framework (NIF) Standard Ontology (https://github.com/SciCrunch/NIF-Ontology).

Multilexicon analysis

In order to explore the prevalence of each lexicon in SEPEX abstracts, we first counted the amount of terms that appeared at least once in the abstract of each edition. We then computed a raw prevalence index for each lexicon by dividing the number of terms from that lexicon that existed in the abstracts by the total amount of concepts of that lexicon. This raw measure provides a first glance into the prevalence of each lexicon. However, it is not ideal, since it penalizes larger lexicons and favors small ones (e.g. for a lexicon of 100 terms, a raw overlap of 10% would indicate that 10 terms from that lexicon were found in the abstract. However, for a lexicon of 1000 terms, the same raw overlap of 10% would correspond to the much larger amount of 100 terms). To account for this and obtain a weighted prevalence index, we normalized the raw prevalence by corpus size. Finally, to explore the relative prevalence of each lexicon compared to the sum of all lexicons, we converted the weighted prevalence indices to percentages. This allowed us to obtain an index of the contribution of each lexicon to the total overlap between (all) lexicons and the abstracts of each SEPEX edition. Additionally, we computed the amount of occurences of each term from each lexicon in the abstracts of each SEPEX editions. This allowed us to assess the prominence of different terms by displaying word clouds for each lexicon and edition. In the word clouds, the bigger the word, the more frequent this word is in the abstracts.

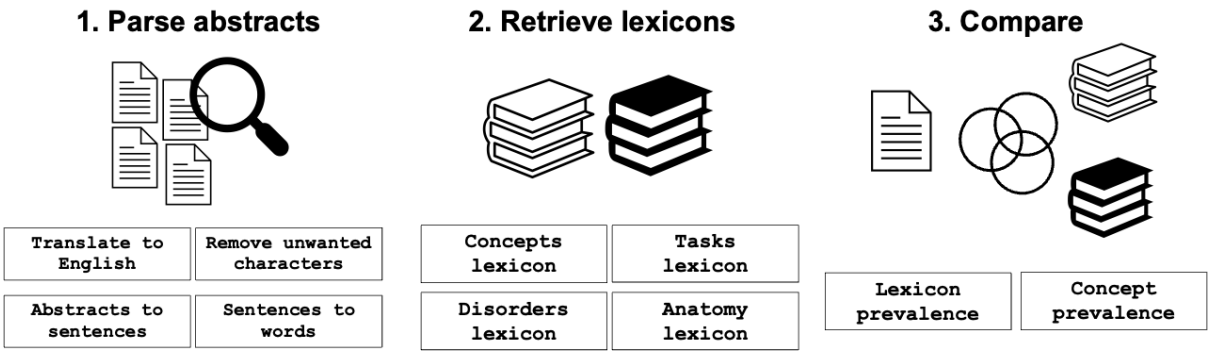

Figure 1. Multilexicon analysis procedure

Analysis of overlap between SEPEX and William James' writings

To explore the prevalence of pre-scientific terms in SEPEX abstracts, we first created "SEPEX lexicons" by parsing the abstracts and checking the overlapping terms with the different lexicons described above. Then, we loaded the preprocessed James' Principles of Psychology file and compared the number of occurrences of each term of the SEPEX lexicons in the text, correcting for lexicon size as before. This allowed us to, first, compare the proportion of SEPEX terms from different lexicons found in the text of James, across SEPEX editions. Second, it allowed us to assess which specific terms from the SEPEX lexicon were shared with James and which SEPEX terms did not overlap with James.

RESULTS

Predominance of conceptual aspects

To obtain a general overview of the predominance of the different lexicons, we averaged the prevalence index (PI) of each of these across SEPEX editions. This analysis revealed a strong predominance of the Concepts lexicon (PI = , CI = [x,y]) compared to any other lexicon (descriptives). Moreover, the results were not affected by lexicon size. When using the weighted prevalence index (WPI = PI / total number of words found in SEPEX abstracts across lexicons), results were similar (Figure 2A), with an order of magnitude higher WPI for Concepts (M = 0.000073 , SEM = 0.000008) than Disorders (M = 0.000015 , SEM = 0.000004), Tasks (M = 0.00001 , SEM = 0.000002), or Anatomy lexicons (M = 0.000001 , SEM = 0.002). Additionally,

when considering each SEPEX edition individually, we observed little variation and an overall stable pattern with, again, predominance of Concepts over other lexicons, and a considerably low presence of task, disorders and anatomy aspects (Figure 2B). A one-way ANOVA across editions confirmed the main effect of Lexicon ($F_{3,12}$ = 82.32, $p < 0.0005$, $n_p^2 = 0.95$). Post-hoc paired t-tests (Bonferroni corrected for multiple comparisons) yielded significant evidence for a higher WPI of the Concepts lexicon compared to anatomy ($p = 0.005$, Cohen's $d = 5.1$, BF10 = 40.46), disorders ($p = 0.003$, $d = 4.04$, BF10 = 69.241), and tasks ($p = 0.004$, $d = 4.63$, BF10 = 51.9). All other contrasts did not reach significance (all *p*s > 0.078).

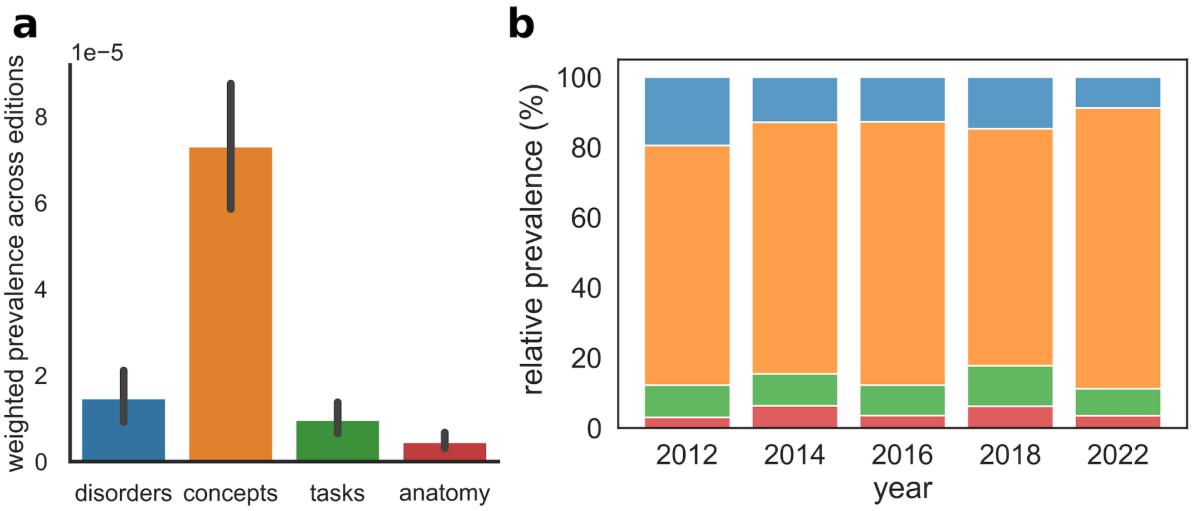

Figure 2. (a) Average prevalence of lexicons in SEPEX abstracts, corrected for lexicon size. (b) Weighted prevalence of each lexicon on 5 different SEPEX editions.

Prominent terms in SEPEX abstracts

In order to better understand the conceptual landscape of the SEPEX from a bird's eye-view, we generated wordclouds (see Methods) with the most prominent terms in SEPEX abstracts from 5 different editions, across our four lexicons. These wordclouds reveal a few features of the SEPEX semantic space (Fig. 3). First, there is a strong consistency across editions in the most prominent terms. This is primarily the case for concepts (with terms like *memory*, *language*, *attention*, and *learning* reigning the cloud) and anatomy. In this regard, the anatomy clouds display an overrepresentation of general structures (i.e. "brain") which in turn shows a lack of

precision when referring to neural terms. Regarding the Tasks lexicon, the wordclouds show no clear predominance of specific terms beyond “reaction time”, which suggest little consistency in the naming of tasks used by SEPEX members. Finally, the Disorders wordclouds reveal a relatively scarce presence of clinical terms in SEPEX abstract, which might indicate a reduced interest in clinical populations.

Figure 3. Wordclouds with the most prominent terms in SEPEX abstracts spanning 10 years, across lexicons.

Spanish psychological ontology relies on pre-scientific terms

Given the clear predominance of Conceptual terms in SEPEX abstracts, we decided to further explore some features of the most frequently used terms by members of the Society. Specifically, to address claims about the folksiness of Psychology's ontology, we evaluated the degree of overlap between these terms and terms already used before the establishment of experimental psychology as a scientific discipline. To do so, we compared the SEPEX ontological space with James' Principles of Psychology (see Methods). First, we observed, across five SEPEX editions (10 years), a great predominance of the Concepts lexicon in the total overlap with James writings (Figure 4A). A one-way ANOVA revealed a main effect of Lexicon ($F_{3,12}$ = 2415.46, p = 2.33744e-08, n_p^2 = 0.99) and post-hoc tests confirmed the significantly higher overlap of James with the Concepts lexicon compared to the Disorders (p < 0.0005, Cohen's d = 60.7, BF10 = 9.167e+04), Tasks (p < 0.0005, Cohen's d = 63.3, BF10 = 5.005e+04), and Anatomy (p < 0.0005, Cohen's d = 35.41, BF10 = 3803.469) ones. The surprisingly high overlap (mean across editions = 47.06%) shows that almost half of prominent SEPEX terms are shared with James. This proportion is at odds with the overlap with other lexicons as well as the overlap found between other disciplines and corresponding seminal texts (Poldrack, 2022). When analyzing this overlap in more detail, we observed that SEPEX terms that appeared most frequently in James' writings were the same terms that were most predominant in SEPEX abstracts ("*attention*", "*learning*", "*memory*", "*language*", etc.; see Figure 4B, left). Interestingly, this analysis also allowed us to look at predominant SEPEX terms that were *not* used by James, suggesting a departure from pre-scientific terms. As can be seen in Figure 4B (right), some of these are mere atomizations of previous terms (e.g. working memory). However, this wordcloud also shows current popular topics that might be interpreted as less folksy than the previous ones (e.g. retrieval, cognitive control, priming, etc.).

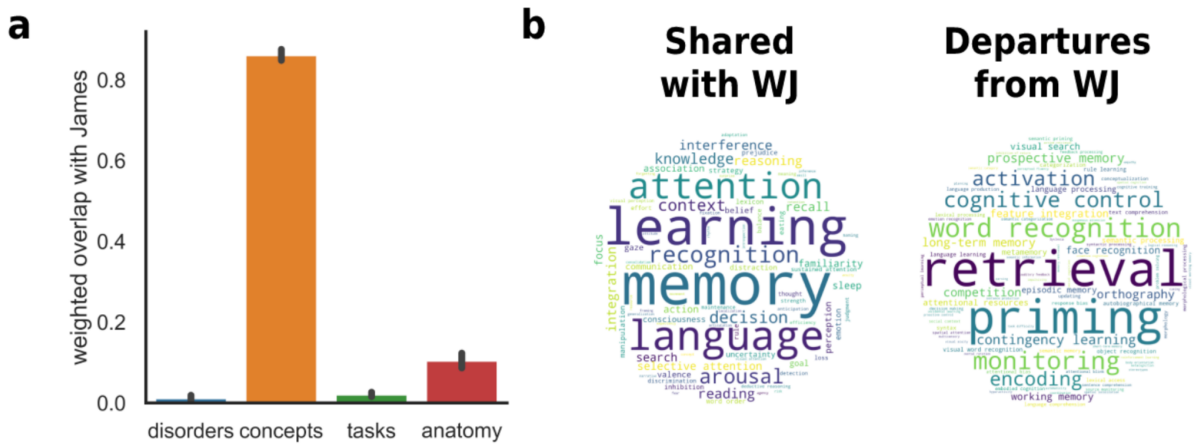

Figure 4. (a) Overlap between SEPEX prominent terms and William James' writings. (b) most prominent terms shared with James (left) and terms prominent in SEPEX abstract that do not appear in James' texts (right).

DISCUSSION

Appropriate theory building requires a firm foundation on top of which a discipline can grow. We argue that an agnostic (i.e., data-driven) examination of a discipline's commonly used terminology can shed light on the robustness of its conceptual ground. Here, we followed this approach to look at Experimental Psychology in the Spanish context with the goal of 1) revealing underrepresented areas of exploration and research domains that are overexploited 2) potentially informing future research decisions as well as explicit talent-seeking strategies and funding policies. Furthermore, we argue that this kind of examination can also provide key insights into the nature of the object of study of Psychology as a discipline.

Our results revealed a clear predominance of Concepts over other types of terms such as the ones related to disorders or anatomy. This pattern was consistent across editions. This is likely to indicate that most of the research conducted within the Spanish community (at least for the last ten years) is devoted to the study of cognitive constructs with little translation into the clinical domain or the neuroscientific community. Whereas the little prevalence of neuroscientific vocabulary can be explained in terms of discipline specialization (see more on this below), the underrepresentation of clinical terms is more likely to reflect selective (perhaps implicit) biases away from the applied domain. This finding reveals an

underexploited niche which, on the one hand, could invite new applied research projects and, on the other hand, could prompt SEPEX to actively try to attract new talents from clinical settings. Either one of these approaches (or a combination of both) would enrich the SEPEX landscape by integrating the application of its basic research into a broader societal picture and benefit clinical research by harvesting the careful methodological expertise of the SEPEX community.

Another striking finding was that the most commonly used Concepts were already present in James' writings. This can be interpreted as a lack of critical methodological and/or theoretical break-throughs in the past 100 years. On one hand, the prolonged use of pre-scientific terminology could mean that Psychology struggles to find qualitatively new models of mind functioning. All critical events across scientific domains, such as the Theory of Evolution, the discovery of the DNA or the postulation of Theory of Relativity gave rise to a whole new terminology that inspired and shaped research from there on. It is possible, then, that Psychology's last breakthrough was William James's Principles of Psychology. On the other hand, a lack of methodological break-throughs could also prevent us from abandoning old terms. Although the development of new technologies and methodologies usually follows theoretical leaps, the extent to which this penetrates mainstream language is often led by technology. For instance, the availability of atomic microscopes or telescopes for Deep Space exploration democratizes the use of novel terminology mostly because they allow the exploration of new phenomena that were not reachable before. The surge of Neuroimaging tools and computational approaches in the past twenty years has for sure generated new terminology. However, the little prevalence of anatomical terms (and the lack of a growing trend in the past ten years), seems to suggest that Experimental Psychology has not (yet) yet fully embraced this new wave nor seized this opportunity to update its vocabulary.

As noted in the introduction, a potential alternative explanation for the exacerbated use of folksy terminology within Psychology concerns its subject of study. Indeed, a big part of the endeavor of Psychology is to explain subjective experience, be it the retrieval of a memory, changes in the attentional state or syntax comprehension. As a consequence, the terminology used in common daily-life situations might be inherently intermingled with the *explanandum*. As such, even if departures from

merely folksy descriptions of the phenomena might be desirable, a complete elimination might be hard to conceive. Although this can be a somewhat comforting alternative account of the results presented here, the reader should be wary when discarding this as an idiosyncrasy of Psychology. First, doing so would endow Psychology with a halo of uniqueness that would make it special within the otherwise homogeneous scientific world. This is very unlikely to be true and, if it were, it would raise more questions than answers (Bishop, 2019; Barrett, 2006; Fiske, 2020). Second, if proximity between the subject of study and daily-life experiences is the explanation, several other disciplines should also be affected in the same manner. This does not seem to be the case for biology or medicine, which eminently address the study of life and health, and suffer much less from this issue (e.g., Poldrack, 2022). Other social sciences such as Sociology, have not been explored yet in this regard and future works would potentially shed light on the matter. To sum up, either if the reader were to fully discard folk insight as non-scientific or to fully embrace it as a research question, the field could benefit from a more prominent effort to operationalize definitions (preferentially beyond verbal descriptions). Such an effort would minimize the reliance on rather abstract and essentialist terms that leave room for subjective interpretation and, as consequence, personal biases and misunderstandings (Brick et al., 2021).

Finally, we acknowledge that moving on to a fully operationalized definition of some psychological constructs might not be straightforward (although desirable). Hence, a short-term change is most likely not-feasible. However, one area in which this change could be a proximal goal is on the labeling of the experimental tools used to obtain measurements. Our results suggest that there is little agreement in the terms that Psychologists use to *name* their tasks. Whereas knocking out a gene or administering a chemical compound are very precisely characterized experimental techniques, cognitive paradigms can sometimes lack a common framework or even a convention on how to refer to them. For instance, a task in which participants are exposed to a set of stimuli in preparation for a subsequent memory test can be named as encoding task, orienting task or cover task, likely revealing the experimenter's background, intention, and/or her subjective interpretation of *what happens in the task*. This would be a situation in which the different labeling of the experimental task 1) could introduce personal biases with respect to the cognitive

operations needed to solve the task and 2) would hinder future reviews and meta analytical work attempting at extracting commonalities across studies. A good example of a task that is carefully defined and with a high agreement across studies, is the n-back task (Kane et al., 2007). This is an example in which a label (i.e., “n-back task”) is associated with a non-essentialist, precise definition (i.e., “task in which participants see a stream of stimuli and they judge whether any given stimuli is identical as the one presented *n* trials before) and which focuses only on the computations needed to solve the task (i.e., compare trial t with trial t-n). Agreeing on labeling our experimental manipulations is key when building knowledge across studies or when looking for synergies with other behavioral, neural or biological markers (see Poldrack et al. (2011) for an attractive proposal in this line).

Caveats and limitations.

The results encapsulated here aim at drawing a first picture of the current conceptual structure of Psychology within the Spanish context. This picture is however somewhat limited. First, we used abstracts from the last five editions of the national SEPEX conference. One might argue that this conference might not be representative of the entire experimental Psychology community in Spain and that some of the patterns shown here (e.g., the reduced use of anatomical terms) might not be such in other specialized societies (e.g., SEPNECA). Future applications of the current approach to other scientific conferences could indeed provide a richer picture. However, it is also worth noting that among the five SEPEX editions included here, four of them were jointly organized with international societies (2012: *Belgian Association for Psychological Sciences*, Belgium; 2016: *Experimental Psychology Society*, UK; 2018: *Associazione Italiana di Psicologia*, Italy; 2022: *Associação Portuguesa de Psicologia Experimental*, Portugal), which partially extends our findings beyond the Spanish borders and it is likely to reflect international tendencies (Poldrack, 2022). Moreover, the fact that we analyzed only abstracts and not full papers might also have an effect on the results reported here. For instance, it is possible that authors tend to speak in more conceptual terms in the abstract of a paper, and to omit certain details, for instance, regarding the specific task used, or specific anatomical results. Thus, to have a more complete picture, it would be desirable for future research to apply similar analyses to full texts of a representative sample of the SEPEX scientific production.

Conclusions

The exploration of the terminology commonly used in a discipline can provide key insights into its conceptual grounds and current developments. Here we provide a critical view on the concepts used in Experimental Psychology and argue that a lack of standardized non-verbal definitions of psychological constructs can slow down strong theory building. We further suggest that adopting community-wide naming conventions and promoting efforts to incorporate proximal disciplines (e.g., Cognitive Neuroscience and Clinical Psychology) will be key to ensure significant advances in the field.

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Conflicts of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Supplementary material

All data and scripts to reproduce the reported results and figures are available at: https://github.com/gonzalezgarcia/sepex_ontology