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REVIEW

How to write the discussion section of a scientific article

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ABSTRACT. The Discussion is the hardest section of a scientific article to write, as cognitive skills must be used to properly contextualize the findings of a study. In this article, we guide scientific writers, particularly unexperienced ones, on how to structure a Discussion section based on an article by Docherty and Smith (1999). According to these authors, a discussion should be prepared by organizing information in the following order: (a) statement of principal findings; (b) strengths and weaknesses of the study; (c) strengths and weaknesses in relation to other studies, discussing particularly any differences in results; (d) meaning of the study: possible mechanisms and implications; and (e) unanswered questions and future research. Each component of this sequence is discussed in detail with examples drawn from the literature.

Keywords: writing the discussion; discussion section; conclusion; scientific writing.

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Introduction

In the natural sciences, the Abstract, Introduction, Material and methods, Results and Discussion (AIMRaD) structure has been used in scientific papers. Some variations in this structure can be found in journals such as Nature and Plant Physiology, in which the Material and methods (or Methods) section is included in the final part of the paper (AIRDaM). Another structure variation permitted in some journals involves presenting the Results and discussion in a single combined section sometimes followed by the Conclusion [AIM(RaD)C]. The Results and discussion are usually combined in shorter articles (Cargill & O'Connor, 2009).

The Introduction and Discussion should function as a pair (Day & Gastel, 2006). The Introduction opens with a broad focus and concludes by more closely referring to the present study (narrowing focus), whereas the Discussion opens with a narrow focus (your findings) and ends with a broad focus (contextualizing your findings to the field at large). Many elements of the Introduction section are used in the Discussion in reverse order. In the Introduction, these elements are used to position the reader within the current state of research, whereas in the discussion, these elements are generally used to interpret results (Glasman-Deal, 2010). The Introduction poses one or more questions, while the Discussion answers what is asked in the Introduction (Day & Gastel, 2006).

The content of the Discussion is more difficult to define than the content of other sections (Day & Gastel, 2006). The main function of the Discussion is to answer the research question posed in the Introduction and to use the study's results to pose an answer (Foote, 2009), or according to Annesley (2010), the Discussion explains what the study results mean and what contributions the paper makes to the area of study. More pragmatically, in the Discussion you explain how you arrived at the conclusion (Hofmann, 2014). Overall, the following questions should be considered when this section is drafted (Docherty & Simith, 1999; Foote, 2009; Annesley, 2010; Hofmann, 2014, Wallwork, 2016):

(a) What are the most important findings of your study?
(b) Did you reject the hypothesis?
(c) Did your findings suggest an alternative hypothesis?
(d) What are the strengths and weaknesses of your study?
(e) What other factor(s) could have influenced your findings?
(f) How are your findings related to those of other relevant studies?
(g) Why are the findings of your study different from those of other studies?
(h) What are the strengths and weaknesses of your study in relation to other studies?

(i) Did you explain unexpected findings?

(j) What assumptions did you make upfront?

(k) How do your findings fit with existing knowledge on the topic?

(l) How do your results influence knowledge of the problem examined?

(m) Why are the contributions of your study important?

(n) Can you improve your hypothesis or model?

(o) What mechanisms explain the phenomenon explored?

(p) Is there a theoretical implication or a practical application of your study?

(q) Did you propose changes to experimental designs to be applied in future studies that could address the problems or limitations you experienced?

(r) What new questions emerge from your study?

(s) What generalization can be drawn from your study?

(t) How could your findings be generalized to other areas?

(u) What further research would be needed to explain the issues raised by your findings?

Given the Discussion's broad focus, researchers tend to experience difficulties when writing this section. Too often, the significance of the results is not discussed or is not discussed adequately. Even when data included in a paper are valid and interesting, a poor interpretation of data can lead a journal editor or reviewers to reject the manuscript (Day & Gastel, 2006). As a common mistake, many young researchers limit the discussion to a comparison of their results to the results of other researchers. In addition to these mistakes, you should avoid the following when writing a Discussion (Hess, 2004; Hofmann, 2014; Wallwork, 2016):

(a) Including too little or too much text.

(b) Including text without structure (open with a narrow focus and then generalize).

(c) Including data not presented in the Results section.

(d) Describing detailed aspects of the results. To relate results to interpretations, use "bridge sentences" as shown in example 1 in bold + *italic* (*suggesting that*). A "bridge sentence" is also used in example 2.

(e) Emphasizing irrelevant and incidental findings (remain focused on the hypothesis).

(f) Presenting ambiguous data source (are you writing about your study or about another study?). Avoid this problem by using terms such as those in bold + *italic* in example 2.

(g) Criticizing other researchers (be professional).

(h) Making unwarranted speculations.

(i) Overstating the importance of your findings.

(j) Presenting conclusion not supported by data or overgeneralizing the findings.

(l) Arriving at conclusions not related to objectives presented in the Introduction.

1) "Plant growth promotion (PGP) by Ct was shown to be tightly regulated by Pi availability, '*suggesting that*' beneficial activities of the fungus are conditional upon particular environmental conditions... (Hiruma et al., 2016, p. 471).

2) '*Previous reports*' of mcr-1 associated resistance in Egypt found mcr-1 in an isolate of E. coli from a cow displaying subclinical mastitis [58] and in a human clinical case associated with bacteremia [59] suggesting that mcr associated resistance would also appear to be emergent in Egypt where the isolates '*of the present study*' were sourced... '*This study*' was also able to review the mcr-2 prevalence among our collection and '*we were unable*' to detect the gene in any isolates examined" (Barbieri et al., 2017, p. 8).

Writing the discussion

As a first step in preparing this section, you should prepare an outline to organize your thoughts in a logical form. To avoid obscuring your message with peripheral issues, keep the objective/hypothesis of your study in mind during the writing process. (Michel, 2012). For long discussions, consider using subheadings to highlight the main points you wish the reader to understand (Cargill & O'Connor, 2009). To avoid plagiarizing, write the Discussion in your own words after interpreting, summarizing and generalizing relevant papers. Use the first person and the active voice to make your discussion more lively and interesting. You should consider using 'we' even when you are the only author of the paper. Use the past tense when referring to your findings, and use the present tense when referring to general or true information. Additionally, use the present tense when answering a question or stating your study's

significance (Hofmann, 2014). The present perfect (for example "we have described") should be used to describe what you have accomplished through the writing process (Wallwork, 2016).

The sequence of the Discussion section varies from author to author. In an attempt to improve standardization, Docherty and Smith (1999) proposed a structure for Discussion sections. According to these authors, a structure helps a reader to find specific information from the Discussion and signals to the writer the most important topics to cover in this section. These authors recommend using the following structure that opens with specific information and closes with generalized statements:

a) Statement of principal findings.
b) Strengths and weaknesses of the study.
c) Strengths and weaknesses in relation to other studies, discussing particularly any differences in results.
d) Meaning of the study: possible mechanisms and implications.
e) Unanswered questions and future research.

While this structure is not a "one size fits all" formula, it may help young researchers efficiently prepare this important section of a scientific paper. Information not explicitly included in the structure proposed by Docherty and Smith (1999) is included by us given that we judge this information as important.

Statement of principal findings

Open the discussion by briefly restating the key finding(s) of your study as shown in examples 3, 4, and 5. The key finding(s) should address the research question/purpose stated in the Introduction using the same key terms (Hofmann, 2014). If the research question was only answered partially, explain which aspects of the question were answered and why. The answer to the research question represents the culmination of the paper. Hence, it should be included in the beginning of the Discussion (Annesley, 2010) and should be used to initiate a discussion of broader implications or generalizations drawn from the results (Glasman-Deal, 2010). After stating the relevant results (positive or negatives), you should, when appropriate, present supporting evidence or other important findings. Secondary results should be summarized and generalized rather than repeating what was found (Hofmann, 2014). When necessary, mention the figures or tables in which results are presented (see examples 3, 4, and 5). In example 5, the authors include a statement ("*To our knowledge*...") that calls attention to the novelty of their study.

3) Here we show that wild bee pollinators provide important pollination services to crops around the globe with the economic value of this ecosystem service being on par with that provided by managed honey bees (Kleijn et al., 2015).

4) "The present study demonstrates the protective effects of oral administration of Lactobacillus gasseri SBT2055 (LG2055) against influenza A virus infection. This effect enables mice to be resistant to a virus infection as shown by improvements in the survival rates and by decrements in the virus titer in the lungs" (Nakayama et al., 2014).

5) "Soybean plants grown from seeds containing 5.35 mg kg^{-1} Ni showed a significant yield increase up to 25 % in response to external Ni supply, in spite of the fact that these plants were neither dependent on N_2-fixation nor treated with urea. To our knowledge, a statistically significant seed yield response to Ni supply in nutrient solution is reported for the first time for a crop plant in the present study" (Kutman, Kutman, & Cakmak, 2013).

Alternatively, before presenting your key finding(s), you can begin the Discussion reminding readers of important information included in the Introduction section and/or in the Material and methods section to contextualize your study. In examples 6 and 7, the Discussion begins with general information recovered from the Introduction: "Imidacloprid is a widely used..." or "ABA is an essential phytohormone..." Next, the authors describe gaps in the knowledge, which are usually reported in the Introduction: "...but no studies have previously examined..." or "...has not yet been characterized in detail." In example 8, the authors open the Discussion by reminding the reader of information reported in the Material and methods section: "In this study, two transgenic lettuce lines..." In example 9, the objective of the study is described ("The objective of this study was...") followed by a description of information drawn from Material and methods section ("Genotypes were compared based on..."). In these four examples, the key results are presented following a contextualization: "...we show that..." (example 6), "...we found that..." (example 7), "...this work demonstrate that..." (example 8), "The results for..." (example 9).

6) "Imidacloprid is a widely used neonicotinoid pesticide throughout China, but no studies have previously examined its effect on olfactory learning, a key element in successful foraging, for an economically and ecologically important native bee species, *A. cerana*. In adult bees, we show that ingestion of 0.1 or 1 ng/bee reduced olfactory learning acquisition, which was 1.6-fold higher in control bees" (Tan et al., 2015).

7) "ABA is an essential phytohormone regulating seed maturation, germination, stomatal closure and various stress responses. However, the effect of ABA on cellular growth and morphogenesis has not yet been characterized in detail. Here, we found that epidermal cells developed ectopic protrusions in seedlings germinated and grown in the presence of ABA" (Takatani, Hirayama, Hashimoto, Takahashi, & Motose, 2015).

8) "In this study, two transgenic lettuce lines (AVPD1-2 and AVPD1-6) with enhanced H+-PPase abundance and activity were used to evaluate the potential of this genetic manipulation for improving NO3- uptake efficiency in lettuce. The experiments described in this work demonstrate that this technology was instrumental in improving lettuce N use efficiency under control and limiting NO3- regimens in laboratory, greenhouse, and field scenarios. In all instances, more production (including marketable yield) was obtained per unit of N input for AVP1D-engineered lettuce versus controls" (Paez-Valencia et al., 2013).

9) "The objective of this study was to determine if there were genetic differences among common bean genotypes in the threshold at which N_2 fixation declined during soil drying. Genotypes were compared based on daily measurement of ARA over a soil drying cycle. The results for all cultivars were well-represented by a two-segment linear regression " (Devi, Sinclair, Beebe, & Rao, 2013).

Strengths and weaknesses of the study

Here, you must highlight the strengths and weaknesses (or limitations) of your methods and approach (Wallwork, 2016). Although the strengths of the study can help convince readers of the validity of conclusions drawn (Falavigna, De Foite, Blauth, & Kates, 2017), editors and readers are likely to be most interested in the limitations of your study. Thus, place equal emphasis to both strengths and limitations (Docherty & Smith, 1999). Limitations are generally discussed while assuming that there is no evidence to reject your hypothesis and that the experimental design used is reasonable (Wallwork, 2016). If you do not criticize your own study, be sure that the reviewers will do so. We present study limitations in papers for ethical and pragmatic reasons. As a pragmatic reason, limitations indicate to readers which 'mistakes' we made (Wallwork, 2016) so they can avoid making similar mistakes. You must explain the reasons for the limitations found (Falavigna et al., 2017) and explain the implications of these limitations for the conclusions of your study. You may even propose modifications and improvements to the study design to minimize or eliminate "mistakes" from affecting future work. In specific situations, you can lessen the impact of limitations by noting that other researchers have had experienced similar problem or that the current state of knowledge is unable to resolve the problems that you have encountered (Wallwork, 2016).

In examples 10, 11 and 12, the authors describe the limitations of their studies: "*An important caveat for interpreting our study is that…*", "*One inherent weakness of this study…",* or *"Another important limitation…"* In example 10, the authors propose modifications to the methodology used for improving future work: ("*…further research should be done with more species-rich communities*). In example 11, the authors comment on limitations of the study concerning its temporal and geographic relevance, which limits the generalization of the conclusions drawn. In example 12, confounding variables interfered with the results and the authors note how they tried to control them ("*…we tried to control for…*"). In example 13, the strengths of the study ("*This study has several strengths*.") are clearly highlighted ("*First… Second…*"). In example 14, both strengths ("*This study has some strengths…")* and limitations ("*…the number of participants in the study was relatively small and they were mostly French-speakers…*") are noted. In addition, these authors clarify that limitations restrict the study's conclusions (*…might limit the transferability of the results to a particular cultural context …*").

10) "An important caveat for interpreting our study is that we used four-species mixtures, and four species per m^2 is lower than in most grasslands. A relatively small number of species was used in this study due to its focus on dominance and evenness, and further research should be done with more species-rich communities" (Huang, Martin, Isbell, & Wilsey, 2013).

11) "One inherent weakness of this study is its restricted temporal and geographic relevance. A single season of field data conducted at a single site in the northern portion of the plant's geographic range limits inferences that can be drawn from the data" (Frye & Hough-Goldstein, 2013).

12) "Another important limitation is that there were differences in age, sex ratio and BMI between the two study groups resulting in an unmatched case–control study. However, we tried to control for these confounding factors during the logistic regression analysis of the study" (Dimitriou et al., 2015).

13) "This study has several strengths. First, we were able to adjust for many covariates that could potentially confound our associations. Although no data was available about complications that occurred, length of hospital stay was used as an indicator of major complications after surgery. Second,..." (van Zutphen et al., 2017).

"This study has some strengths, including the use of a mixed-method design that enabled us to explore in depth the quality of life of participants with various adapted sports' backgrounds and triangulate the quantitative and qualitative data. The entire team was involved in the analysis, and the triangulation of the researchers' perspectives enriched the results. The participants in the qualitative component also had different characteristics, which allowed us to explore a variety of experiences. However, the number of participants in the study was relatively small and they were mostly French-speakers, which might limit the transferability of the results to a particular cultural context..." (Côté-Leclerc et al., 2017).

Strengths and weaknesses in relation to other studies, discussing particularly any differences in results

Once key findings have been presented and once the strengths and weaknesses of your study have been noted and discussed, the next step is to amplify the discussion by commenting on the key findings of your study in relation to studies available in the literature. Confine yourself to discuss relevant work conducted in your field. Although you can mention studies not mentioned in the Introduction, it is not common to refer to a large number of studies for the first time in the Discussion (Glasman-Deal, 2010).

Your study may confirm (you could write: Our study confirms..., Our results are consistent with...) or contradict (Our study differs from...; However, other studies found that...) the current state of knowledge. Your study can also extend (Our study extends..., Our study adds...) the results of previous studies (Glasman-Deal, 2010) or modify the knowledge in a given area (Our study modifies...). You should also consider how the results of other studies may be combined with the results of your study to better comprehend the problem being investigated (Wallwork, 2016), or you may propose an improved or new model. You should consider using a figure to clarify the model and when appropriate describe ways to validate the model (Hofmann, 2014).

The strengths of your study relative to those of other studies may help you convince your readers about the quality of your research and the correctness of your conclusion, but do not hide the limitations of your study. Knowing the limitations of your study may lead you to restrict generalizations of your conclusions (Cargill & O'Connor, 2009) and to reveal ways to improve future works (Glasman-Deal, 2010). By outlining concrete future strategies to apply, you will make a more convincing case to your readers (Wallwork, 2016). Unless you made so many errors that your results have been rendered unreliable, you certainly learned something from your study.

When describing your study's strengths or limitations, compare your Material and methods section with those of other studies. Overall, differences between results may be explained by the ways in which the results were acquired. If you cannot explain why the results are conflicting, say: We cannot explain why... When appropriate, you should explain assumptions (or premises) made upfront so that the validity of your research can be assessed.

Unexpected findings should also be discussed. If the study was conducted effectively, results contrary to what was expected require interpretation (Wallwork, 2016). These results may lead you to new discoveries and may change the focus of your study (Hofmann, 2014) or may serve as helpful indicators for the progression of knowledge (Wallwork, 2016). When unexpected findings alter the focus of your study, you should signal this to the reader (To our surprise..., Surprisingly...) and describe your unexpected findings briefly (Hofmann, 2014) in a neutral and subjective manner (Wallwork, 2016).

In example 15, the authors describe both the strength and the limitations of their study relative to other studies. After addressing the first limitation, they claim: "This is a major limitation of this study..." In example 16, the authors describe the strengths of their study by exploring points cited in their study and comparing them with those cited in two studies ("Our study was better controlled..."). In example 17, the value of N-resorption efficiency found by the authors (72.1%) is greater than that of a large number of graminoids reported in the literature (58.5%). The authors provide two possible explanations for this difference: one is speculation ("The higher average of N-resorption efficiency in this Stipa species seemed..") and the second is based on methods used for calculation of resorption efficiency ("...this discrepancy may partly result from differences in methods..."). In example 18, after the authors describe the strength of their study in comparison to a study [41], they describe their contributions to current knowledge ("...our study adds to the previous knowledge...").

15) "A particular strength of this study is the use of a nationwide population-based dataset that provides a sufficient sample size and statistical power to explore the association between neovascular AMD and dementia. Nevertheless, some limitations to our study should be addressed. First, neovascular AMD and dementia diagnoses, which rely on administrative claims data and International Classification of Diseases codes, may be less precise than those made according to standardized criteria. This is a major limitation of this study compared with previous studies that used standardized diagnostic examinations of patients" (Chung et al., 2015).

16) "The studies by Shanahan et al. (1990) and Reynolds et al. (1994) were the only ones published thus far indicating a positive association between cellular membrane thermostability and yield under heat stress in different field environments. In these studies the field-testing conditions may have included stresses other than heat, such as drought and various biotic stresses. Our study was better controlled to eliminate any drought or biotic stresses so that heat was the main yield-limiting factor under the summer test conditions" (Blum, Klueva & Nguyen, 2001).

17) "The value of N-resorption efficiency (72.1%) for S. krylovii characterized in the present study was higher than that of a large number of graminoids worldwide (58.5%) reported in the literature (Aerts, 1996). The higher average of N-resorption efficiency in this Stipa species seemed rather to be a consequence of its generally greater fitness to infertile habitats. Further, this discrepancy may partly result from differences in methods used for calculation of resorption efficiency. For instance, we calculated resorption efficiencies based on N pool per plant (g plant-1), while previous studies calculated them on the basis of leaf mass or leaf area (mg g-1 or mg m-2)" (Yuan et al., 2005).

18) "It has previously been found that intention to change food consumption in order to mitigate climate change increases with worry about climate change consequences [41]. We did not study intentions but assessed the actual food intake frequencies. Therefore our study adds to the previous knowledge: the high concern about climate change might actually concretize the intentions to make dietary adjustments" (Korkala, Hugg, & Jaakkola, 2014).

Meaning of the study: possible mechanisms and implications

At this point in the Discussion, you should inform your readers the mechanisms that could have produced the phenomenon and the implications of the results for your research area. According to Illari and Williamson (2012), a mechanism for a phenomenon consists of entities and activities organized in such a way that they are responsible for the phenomenon. Identifying theoretical or practical implications involves finding ways in which your results may be used or may lead to the development of new applications in the future. Listing applications allows the reader to understand the value of your research beyond the narrow objectives of the study (Glasman-Deal, 2010). You must be careful here not to extrapolate the evidence provided by the data. In some cases, it may be wise to emphasize what your results do not indicate, discouraging readers from reaching unjustified conclusions (Docherty & Smith, 1999). It is also possible for your study to have no clear implications (Glasman-Deal, 2010).

Possible mechanisms are noted in example 19 ("...*biochemical mechanism acting as*..." or "...*via a phyB-independent mechanism such*...") and 20 (...*via mechanisms involving*...") for the phenomena examined. In example 21, one mechanism was suggested in literature followed by a mechanism suggested by the study. The implications of study findings are described in examples 20 ("...*an attractive target for preventing or*

treating..."), 22 (*"This finding is likely to have practical consequences."*), and 23 (*"...provides an opportunity for conservation intervention."*).

19) "High fluence rate control could be mediated either through a biochemical mechanism acting as a Pr to Pfr flux counter or else via a phyB-independent mechanism such as photosynthesis" (Johansson et al., 2014).

20) "Thus, intestinal epithelial MyD88 acts as a metabolic sensor that switches host metabolism during diet-induced obesity via mechanisms involving the gut microbiota. These unique features render intestinal epithelial MyD88, an attractive target for preventing or treating diet-induced obesity and metabolic disorders" (Everard et al., 2014).

21) "The decrease in soil microbial biomass has been suggested as one mechanism to explain the decreased microbial respiration (Treseder, 2008; Wei et al., 2014; Riggs and Hobbie, 2016). Our study provides another possible mechanism that the decrease in Rh and increase in SOC could be associated with the changes in microbial CUE and priming effects under N deposition (Fig. 6)" (Liu, Qiao, Yang, Bai, & Liu, 2018)

22) "This finding is likely to have practical consequences. First, studies of gut microbiota should habitually account for sex (and its interactions with other factors) even when there is no main effect of sex... If genotype-by-environment interactions prove to be common in diverse host species, as our results suggest, then therapeutic changes to the environment will not work equally well for all host genotypes, or in both sexes. Consequently, treatment of microbially associated diseases might need to account for these interactions, potentially requiring therapies tailored to host sex and possibly other aspects of host genotype" (Bolnick et al., 2014).

23) "The identification of diclofenac as the cause of the OWBV decline in Pakistan provides an opportunity for conservation intervention. The high rate of visceral-gout-associated vulture mortality in India3,22,23 as well as the widespread use of veterinary diclofenac in India (R. Risebrough, personal communication) suggests strongly that diclofenac may also be responsible for vulture declines in the rest of the Indian subcontinent wherever diclofenac is used for the treatment of livestock" (Oaks et al., 2004).

Unanswered questions and future research

Finally, you should discuss questions that remain unanswered. Briefly propose avenues for future research to further address these questions (Docherty & Smith, 1999). Questions left unanswered in scientific papers are described in examples 24, 25, 26 and 27 and are followed by ways to improve future studies such that they focus on these answers.

24) "A number of questions remain unanswered, such as why the interaction was not detected at S=3. It is obvious, however, that studying global changes simultaneously is essential, as the responses to single changes are likely not additive as also evident from other multi-factorial studies (Reich et al., 2001; Wang, 2007)" (Boeck et al., 2008).

25) "An important, but unanswered, question is how changes in plant architecture, such as those obtained here, will alter the competitive ability of kudzu. Reductions in above-ground and root biomass, in addition to shorter internodes and secondary vine lengths, for plants in the simulated herbivory treatment might limit kudzu's ability to produce adventitious roots at stem nodes, and slow the plant's spread by vegetative reproduction. Additional research is needed to understand how the changes in plant architecture documented here translate to overall plant performance and health" (Frye & Hough-Goldstein, 2013).

26) "Many questions remain to be addressed concerning how these changes influence plant competitive relationships and ecosystem function. Further work is clearly needed to determine how alteration of AMF communities influences plant competitive relationships during C. maculosa invasion and the role played by AMF community composition in determining seedling establishment and subsequent vigor" (Mummey & Rillig, 2006).

27) "Therefore, LG2055 might have other protective effects against influenza virus infection such as enhancement of IgA production. Further investigation is required to better understand the detailed functions of LG2055 to enable the prevention of influenza" (Nakayama et al., 2014).

At the end of the Discussion, you should provide closure by writing a concluding summary of the main points you want the reader to remember (Wallwork, 2016) based on all aspects discussed. The conclusion is the most important message of your paper. Hence, it should be written with great care in the present tense

(use the past tense when describing results). The conclusion (whether in a separate section or not) should match both the question/hypothesis/objective posed in the Introduction section and the main results presented in the beginning of the Discussion section. Base your conclusions on the methods (considering both the strengths and the limitations of the study) and evidence (your findings and the findings of other studies) presented in the article. Both negative and positive findings are equally important to the conclusion.

In the conclusion, readers expect an interpretation of the study's key findings associated, when appropriate, with support from the literature in addition to the study's significance. The significance of the study adds value to the article and focuses on practical applications (…can be used for…), recommendations or opinions (X should be used to…, We recommend that X…), implications (Our results imply…, Y indicates that X might…) or theoretical propositions (We hypothesize that…, Here we propose that…). The level of certainty increases from the theoretical proposition to the description of practical application (Hofmann, 2014). In describing practical applications, you can illustrate the study's relevance beyond your specific research question (Glasman-Deal, 2010). When your study's conclusions are different from your hypotheses, you might suggest, based on what you have learned about the given problem, possible avenues for future research. Conjunctive adverbs generally used for the concluding paragraph include the following: In summary…, Taken together…, In conclusion… (Hofmann, 2014).

In example 28, the authors present a conclusion that addresses the question posed in the Introduction ("The results obtained in this study clearly demonstrated that…") followed by the study's implication ("This trait appears to be a good candidate for…"). In example 29, the authors answer the question raised in the Introduction ("Our results demonstrate that…") followed by recommendations ("Current environmental policy needs to focus more strongly…"). In example 30, the authors present their key findings ("This research has identified…") followed by two implications ("This knowledge will allow for…" and "Increased knowledge of the critical period will also…"). In example 31, the study's novelty is highlighted in the conclusion of the study ("In conclusion, we discovered a novel function of…") followed by a description of its implications ("These unique features render intestinal epithelial MyD88, an attractive target for…"). In example 32, the authors state at the end of the conclusion this implication: "Ni has a high potential to improve the utilization of N fertilizers by soybean…" Emphasizing that this topic has little research, the authors propose that "…future research…" should be conducted to improve the use of N fertilizers for soybean and other crops.

28) "The results obtained in this study clearly demonstrated that genetic variability exists in N_2 fixation resistance to drought. This trait appears to be a good candidate for exploitation in common bean breeding programs to enhance drought resistance of future common bean cultivars" (Devi et al., 2013).

29) "Our results demonstrate that deposition of reduced forms of Nr continues to be of greatest importance in China (which is responsible for approximately 2/3 of total deposition) but emission and deposition of oxidized Nr are increasing more rapidly. Current environmental policy needs to focus more strongly on reducing present NH3 emissions from agricultural sources, whereas control of NOx emissions from industrial and traffic sources will become more important in the near future. It is time for China and other economies to take action to improve N-use efficiency and food production in agriculture and reduce Nr emissions from both agricultural and non-agricultural sectors. These actions are crucial to reducing N deposition and its negative impact locally and globally" (Liu et al., 2013).

30) "This research has identified the critical period for yield determination and the associated critical periods for yield components. This knowledge will allow for more targeted stress mitigation practices, e.g. combining sowing date and cultivar phenology to reduce the likelihood of severe stress in the critical window. Increased knowledge of the critical period will also enhance the ability of breeders to screen for stress tolerance with more targeted stress impositions" (Lake & Sadras, 2014).

31) "In conclusion, we discovered a novel function of intestinal epithelial MyD88. We show that targeting intestinal epithelial MyD88 confers protection or therapeutic effects against diet induced metabolic disorders. Thus, intestinal epithelial MyD88 acts as a metabolic sensor that switches host metabolism during diet-induced obesity via mechanisms involving the gut microbiota. These unique features render intestinal epithelial MyD88, an attractive target for preventing or treating diet-induced obesity and metabolic disorders" (Everard et al., 2014).

32) "All these results together with the proven and proposed roles of Ni in urea and amino acid metabolism indicate that Ni has a high potential to improve the utilization of N fertilizers by soybean and possibly other crops, which represents an important future research topic" (Kutman et al., 2013).

Final thoughts

Writing a Discussion section for the first time is a difficult task. Even for experienced authors, the first version of the Discussion is likely to suffer many modifications as the manuscript "matures". Nevertheless, as with any other activity in life, practicing and evaluating are keys to improving discussion writing skills. We offer two final words of advice: i) read as many papers as you can, and read them critically to learn how important scientific groups communicate results and discuss them, and ii) try to review manuscripts written by colleagues to build a capacity to analyze (separate components of manuscripts to better assess each one), synthesize (put the pieces back together) and evaluate the manuscript as a whole.

Conclusion

When writing a discussion, scientists should carefully think about the subject under investigation, about the quality of work conducted and about what can be modified in future studies. Mastering scientific writing is not an easy task, but it can be a rewarding experience for both novice and experienced authors. Docherty and Smith's (1999) structure for discussions described, commented on and exemplified in this paper embraces major points that should be addressed and may help researchers write this challenging section of the scientific article.

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