IMPROVING COMMUNICATION SKILLS: THE PUZZLE OF PERSONAL STYLE IN ENGINEERING WRITING AND PRESENTATIONS

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Abstract

Awareness of certain aspects of the natures of two major groups of engineers may improve the way faculty work with students on written and oral presentations. The two groups correspond to the different ways that "reasoning" and "intuition" are allocated to the "inner" and "outer" task domains. Reasoning is careful, step-by-step, thorough, and slow, while intuition works quickly—one just "knows" or confidantly assumes "it can be done." Outer tasks include the "practical" specifics of an application and the outline of a paper. Inner tasks deal with applicable concepts or unifying systems and the sentence-level structure of a paper. There is a large group of engineers who apply reason to outer tasks and intuition to inner ones, leading to quick, instinctive selection of relevant concepts followed by lengthy focus on application details. As authors, they spend time on structure, filling in with sentences in a quick, intuitive way. Revision focuses on the outline. But there is another substantial group of engineers who apply reason to inner tasks and intuition to outer ones, investing time in rigorous development of unifying concepts or systems followed by a quick and instinctive application. As authors, they intuit macro structure while focusing care on sentences, often revising details fanatically. The differences between the groups naturally suggest different approaches in working with them on their writing and oral presentations.

1 Introduction

A year and a half ago the assignment of a term paper in a particular graduate engineering course for the first time led to a startling result. The student's papers were not spread across the whole of some quality-level continuum, but fell instead into two distinct groups. Some papers had the expected occasional errors or misstatements or areas of misguided emphasis but certainly seemed quite reasonable for first efforts of students at that level. But the other papers, even from star students who had worked hard at the assignment, seemed like so much fuzzy and disjointed rambling.

A year later, an early check on the simultaneous writing efforts of two graduate-student advisees found one in what seemed like a perfectly natural early-writing stage. But the other ordered the writing stages oddly and with an unnatural emphasis. Advisor curiosity became advisor alarm when a complete draft appeared—it evidenced precisely the same bizarre characteristics as the frustrating term papers! Alarm dissolved to pleased confusion a few weeks later when the same student delivered an oral seminar so beautiful in its clarity that the seminar coordinator volunteered privately afterward, "I guess they won't be needing me [a professor] anymore [if students can present like that]!" Meanwhile, the student with the natural writing process was seen to struggle with the same aspects of oral presentation as his advisor. The contrast in the research efforts of these two students was equally perplexing. The "natural" student seemed always to be a step ahead, doing on his own initiative just what his advisor would do, while the other's futile wanderings, at least on any matter that to his advisor seemed important to the research, continued to baffle.

It was becoming clear that some sort of intellectual-compatibility issue was involved here as with the term papers earlier. It had been long evident that one and only one of these two graduate students was a close match in basic everyday nature to his advisor (guess which?), so it seemed just possible that some issue of basic psychological nature was behind all this. An old joke goes

> **There are two kinds of people, those who divide people into two kinds and those who do not.**

It seemed that sorting this out might require joining the ranks of the former, beginning by following the lead of the many who had gone this way before.

Background

Notions of the natural division of humankind into halves along various lines have surfaced again and again. In 1921, pioneering psychologist Carl Jung critically examined ideas on such polar divisions published from medieval times forward and synthesized that material with twenty years of clinical observations to arrive at the notions of introversion and extraversion [1]. He ultimately realized what earlier writers had missed: the "attitudes" of introversion and extraversion applied separately to each of four psychological functions—thinking, intuition, feeling, and sensing—that he identified as central to the structure of consciousness. Believing in those early years that typically only one of those four develops fully, he arrived at a division into eight psychological types.

Several decades later, Isabel Myers realized from Jung's work and her own observations that by early adulthood typically one of the sensing/intuition pair and one of the thinking/feeling pair are reasonably mature, with one introverted, the other extraverted, and one or the other dominant, resulting in sixteen possible basic psychological structures. She and her mother, Katherine Briggs, devised the now-commonplace Myers-Briggs Type Indicator (MBTI), a psychological testing instrument, in order to investigate the distribution of those sixteen types in various population groups [2].

Psychologists continuing in the Jungian tradition now recognize that up to three of Jung's four functions can be brought fully or nearly fully under conscious control, depending on the level of psychological maturity of the individual. Many combinations result, because either of two choices can develop as the "third function" and in either an introverted or an extraverted attitude.

INTJ	INTP	INFP
intuition	*thinking*	*feeling*
thinking	**intuition**	**intuition**
		thinking

Table 1. Three columns represent three psychological structures common among engineers. The four-letter tag is the Myers-Briggs designator, with the functions listed from top to bottom

the most to least dominant. *Introverted* and **extraverted** attitudes of individual functions are indicated by typeface. The attitude of the dominant function is by convention considered the attitude of the overall personality, so all three of these types are introverts.

The three types in Table 1 appear by far the most common among engineering graduate students at Michigan Tech. And the variations arrived at by swapping the top two in a column, which turns these "I" introverts to "E" extraverts, are not rare.[1] Nearly all the male engineers seem to be NTJ or NTP, with the NTJs far more numerous. All three types shown are found among the women engineers, but the INFP type shown appears the most frequently. So, having gone from two types to eight to sixteen to many more, we can now narrow our scope to those for whom the intellectually central functions of thinking and intuition are strongly developed.

This paper has developed from the observation that when an engineer's intuition and thinking are opposite in attitude, as in these NTJ and NTP types, a great deal about the writing process (and style) appears determined by which is introverted and which is extraverted. We will focus on these two groups of engineers then, because they naturally evolve as individuals towards fundamentally different writing strategies and processes, and it is becoming clear that a faculty member helps an INTJ student very little by insisting that he tackle a writing task in an INTP manner, or vice versa. Faculty awareness of and respect for both writing processes is invaluable.

But making use of these differences when helping a student with writing requires some confidance in the student's type. Relying solely on tests is discouraged by most Jungian psychologists (*e.g.* Sharp [3, pp. 92, 94]), and indeed the tests seem to routinely misidentify our INTP engineers as INTJ. Part 2 of this paper therefore discusses some recognizable differences between the two groups of engineers. The complexity of human nature has ensured that *no accurate canonical description of the types has yet been written or is ever likely to be,* so these ideas are but a starting point for observing and reflecting. The Part 2 background is also the key to understanding the Part 3 speculations on how the NTJ/NTP differences might systematically lead to the different writing processes observed. Part 4 illustrates ways in which faculty might use these ideas even as they gain the experience with them that we hope will ultimately lead to their further refinement.

2 NTJ Engineers and NTP Engineers

We first examine the two types of thinking, as the contrast between them seems to characterize the extraversion/introversion axis in intellectual matters for both thinking and intuition.[2] The complementary intellectual role of intuition in these two types is then examined.

Two Types of Thinking

Jung's examination of ideas on the "two" types revealed a bewildering variety of observations. But to Jung the difference could always be attributed to an *extraverted* focus of psychological energy outward

[1] The preponderance of introverts is clear. One internet wit recently noted that the difference between an introverted engineer and an extraverted engineer is that the so-called extravert looks at *your* shoes when speaking to you.

[2] Keep in mind that in this context, *thinking* refers specifically to logical reasoning. The everyday use of the term is much broader. "I suddenly thought of..." may refer to intuition and not thinking in this strict sense. "I think that so-and-so is a great person" probably refers not to thinking but to feeling, a function that assigns values.

towards the "object," the separate things, crisp facts, and people of the world, or an *introverted* focus inward towards the "subject," towards the more abstract, towards impressions, unifying concepts, and idealistic feelings, with less connection to the world than to one's reaction to it.

Introverted Thinking Commentators have often cited introverted thinking's characteristic devotion to, as philosopher William James put it, "abstract and eternal principles," seeing "mainly the similarities between objects, and disregard[ing] their singularity" [1, p. 300]. Myers observed that thinkers of this type "focus their thinking on the principles underlying things rather than on the things themselves" [2, p. 89], and that "they are quite likely to be more interested in analyzing a problem and discovering where the solution lies than in carrying out their ideas. They formulate principles and create theories; they value facts only as evidence or as examples for a theory, never for their own sake" [2, p. 91]. And Gross [4] felt that for the introverted thinker, "the inner facts, abstractions, ideas, or universals always occupy the foreground; for him they are the only true realities, to which he *must* relate all indivicual phenomena" [1, p. 282]. Jung's own synthesis points in the same direction: "With regard to the establishment of new facts it is only indirectly of value, since new views rather than knowledge of new facts are its main concern. It formulates questions and creates theories, it opens up new prospects and insights, but with regard to facts its attitude is one of reserve. They are all very well as illustrative examples, but they must not be allowed to predominate. Facts are collected as evidence for a theory, never for their own sake. If this ever happens, it is merely a concession to the extraverted style" [1, p. 380–381].

Extraverted Thinking To William James, extraverted thinking found that "principles are always of less value than facts; if he has any, they merely reflect and describe the flux of events, and are incapable of forming a system" [1, p. 503]. A "lover of facts in all their crude variety" [1, p. 301], he "sees only the individual object and interests himself in its behaviour" and "finds similarities frankly tiresome and disturbing, something that actually hinders him from recognizing the object's singularity" [1, p. 306]. Gross noticed also that the extraverted thinker "is struck more particularly by the individual phenomenon. For him universals are only names lacking reality" [1, p. 282].

This suggests a notion of abstraction that is inherently different from that of the introverted thinker. Jung [1, p. 344] observes that the extraverted thinking function "seems to be constantly affected by the objective data and to draw conclusions only with their consent" and further elaborates [1, p. 310] William James' view: "It is self-evident that for the empiricist ...general concepts are mere derivatives from experience." These general concepts "merely serve to comprise certain groups of phenonema under a collective name. Thus the general concept naturally becomes a secondary factor, having no real existence apart from language." Because here facts are things given from without rather than derived from within, extraverted thinking surely can sometimes include "purely ideal thinking, if for instance it can be shown that the ideas it operates with are largely borrowed from outside, i.e., have been transmitted by tradition and education" [1, p. 342].

Contrasting the Two Extraverted thinking leans to noting and organizing many, many facts, each worthy of respect for its uniqueness and distinction from the others; introverted thinking tends to abstract all into a few key ideas, fundamental concepts, and comprehensive systems of thought. To Myers, "Extraverts find multiplicity rather jolly; but it can be intolerably distracting to introverts unless they can see a unifying meaning that brings it under control" [2, p. 53]. "Problems arise for the introverts because they often do not look closely enough at the outer situation and, therefore, do not really see it. The extraverts often do not *stop* looking at the specific situation long enough to see the underlying idea" [2, p. 54].

William James' view, as expressed by Jung [1, p. 310–311], seems to best contrast the ways the two types relate to abstraction. When the introverted thinker puts forth a new abstraction, the extravert supposes that it "is merely arbitrary choice, or else a premature generalizing of experiences which in themselves are limited." Not so, for this "type draws the energy for his thought-processes neither from arbitrary choice nor from experience, but from the idea." But the extravert "can reach the idea only through the accumulation and comparison of the empirical material. The two types are opposed in a remarkable way: the one shapes the material out of his...idea and thus comes to experience; the other lets himself be guided by the material...and thus comes to the idea. There is comething intrinsically irritating about this conflict of attitude, and, at bottom, it is the cause of the most heated and futile scientific discussions."

As Engineers Engineers with introverted thinking are often tempted to draw back from a real-world issue into a search for a more elegant view, a grand generalization. One universal method or approach or viewpoint or equation is always better than separate ones for separate cases. Using $\cos 1000\pi t$ in teaching makes them cringe. And the intellectual focus can become captivated by a small part of a system, say a single op-amp, leading to remarkable depth at the expense of breadth of coverage. The resulting thoroughness on each bit can make reaching the overall goal difficult.[3]

Engineers with extraverted thinking are usually empiricists, experimenters, hands-on, "practical" engineers. They make measurements, take data, and take data seriously. Often strongly application centered, as reviewers they are likely to ask, "But of what real-world use is this idea?"—though sometimes "real world" to them seems to mean specifically here and now. They are generally comfortable with separate engineering procedures for a myriad of separate situations. Fields where innumerable acronyms and special terms and special procedures are the norm—military electronics comes to mind—are comfortable habitats for extraverted thinking. Their equations are often quite separate as well, each to do with something different, rather than a unified system. They may simply be computational formulae. And what is the big problem with $\cos 1000\pi t$ anyway? How do you expect the students to get the idea except by working with lots of numerical examples?

Because NTJ engineers are so often found in empirical disciplines, it is important to resist the temptation to turn that around and assume that engineers doing empirical work are NTJ in nature. The involvement of NTP engineers in the experimental and empirical work that so dominates engineering is inevitable, and the way their NTP natures colors their work can be quite subtle.

The Role of Intuition

If thinking is either extraverted or introverted, how are the intellectual tasks on which it abstains dealt with? How does an engineer find the relevant concept, abstraction, or principle on which to base his beloved experiment or program or design when extraverted thinking wants get on to the specifics of the case? How does another engineer make numerous minute design decisions without allowing

[3] The field of pure mathematics, with its sometimes bizarre abstractions and its proofs that cover every possible case in excruciating detail, is overwhelmingly the province of introverted thinking.

his introverted thinking to become sidetracked searching for a general principle for each? The slack is taken up by intuition, which has the attitude opposite that of thinking in these engineers and so is naturally focused precisely on those tasks abandoned by the thinking function. Jung explains that intuition "automatically comes into play when no other function can find a way out of a hopelessly blocked situation" [1, p. 367]. In some individuals, it is not just a backup mechanism, but is operating at full bore much of the time, providing a wealth of ideas and inspiration.

This thinking/intuition dichotomy is often easily seen. The NTJ engineers seem to instinctively choose a conceptual approach to a task and proceed to the thinking details of realization or implementation so quickly that they sometimes don't even realize that anything has been accomplished by the choice. "It is obvious what idea applies; let's get on with it!" In the NTP engineers the picture reverses: "Why waste time fussing over the application? It is obvious how to do it!"

An advanced graduate seminar at Michigan Tech last year had three NTJ students and one NTP student. If an example was being developed interactively, it was typically the NTP student who leapt several steps ahead while his colleagues were carefully working it through. But when several examples naturally led to the search for an underlying idea, it was the NTJ students who instantly intuited the principle. The NTP student actually responded, "Yes, but how do you prove that rigorously?" The NTJ students had no idea, but the NTP student soon found a viable approach. Intuition is terribly creative and far faster than thinking, but thinking is far more precise.

3 The Writing of the Two Groups

Four specific speculations appear to account for most of the differences in the writing process that we observe in engineers. Much of this seems to apply to the preparation of oral presentations as well, though with perhaps with some added twists.

Speculation: Macro/micro structure $\longleftrightarrow$ extraversion/introversion.
Creating the macro-structure of a document, the broad outline and flow of topics, is an extraverted task, and creating the micro-structure, the structure at the level of sentence wording and intra-paragraph structure, is an introverted task.

The idea that extraversion is associated with breadth and that introversion is in some way more narrowly focused is a common thread in discussions of all aspects of these two contrasting attitudes [2, p. 54] [1, p. 326] [1, Chapter VI].

Speculation: Intuition drafts words, thinking revises them.
Initially putting words down is an intuitive activity, but their careful revision requires thinking.

The *initial* choice of actual words appears to require the inspirational leap associated with the intuitive function. Indeed, first-draft words often show the intuitive tendencies to unpredictability, eccentricity, lack of precision, fuzziness, disjointedness, as well as sometimes extraordinary creativity. Later revision at the sentence level ("wordsmithing"), where attention is consciously focused on what *exactly* the words are saying, is more of a thinking activity.

Once the first two speculations were in place, discussion with a couple of dozen engineering graduate students and faculty members about their own writing processes led quickly to this:

Speculation: Extraverted writing evolves to introverted writing.
The natural flow of the writing process is from the extraverted part of the personality towards the introverted part of the personality.

In one group then, writing begins intuitively and becomes a thinking process later, while in the other group, it begins as a thinking process, evolving to an intuitive activity towards the end. This evolution is entirely natural if we imagine the writing experience gradually being personalized, drawn inward, and made a part of the writer, who is becoming increasingly involved with the writing task.

Speculation: The thinking phase dominates.
Engineers spend their time on the portion of the writing process dominated by thinking.

If intuition is going to work, it will generally work quickly, so thinking usually dominates the time spent on any particular engineering task. And since engineers then consider the thinking part of their work as the real work, there may be an effect on the value system: the intuitive component of the process is brushed off as peripheral. It is simply assumed that the inspiration will come as needed.

The Engineering-Writing Process

The four speculative ideas above combine directly to paint pictures of the two writing processes that match remarkably well in general outline with our observations. The NTJ process, discussed here first, seems explicitly taught to engineers more often.

The NTJ Writing Process Engineering writers of the NTJ types begin the writing process by applying their extraverted thinking to carefully designing the macro structure, the outline, of the document. It may be on paper, or it may be in the engineer's head, but the outline typically evolves in a goal-oriented manner, aiming perhaps to persuade such and such a specific audience of so and so. This careful, logical evolution and indeed revision of the document structure requires a lot of time and may be taken all the way to the paragraph or subparagraph level before any words are committed to paper. Such writers often report that when they finally begin putting down sentences, the document practically writes itself, as the words just come to them. Once their introverted intuition has provided words, serious wordsmithing would require both an unnatural backing up to extraverted thinking and an unnatural focusing of that thinking on the precise inner meaning of those words, and indeed, these writers seldom revise much, especially early in their development as writers. Ultimately their outlines are likely to show a lot more precision, order, and structure than their individual paragraphs and sentences, where due to the paucity of thinking revision these writers must guard in the final micro-wording against what Sharp calls "gaps in the so-called nonlinear or lateral thinking—the leaping from thought to thought—that distinguishes the intuitive" [3, p. 71].

The NTP Writing Process For the NTP writers, a hazy, intuited notion of document structure may be initially present, but often these writers simply begin with a spontaneous flow of draft text for some obviously necessary part of the document, usually the expression of the core idea. As extraverted intuition gains momentum, the unfolding text gradually takes on such a life of its own that the frantically typing author may even fear leaving the keyboard lest the precious magic of the unstoppable word-generating demon be broken [2, pp. 106, 107] [1, p. 368]. Increasing topical coverage often leads to major rearrangement of substantial text chunks in lieu of any explicit development of an outline. Introverted thinking becomes increasingly involved until the phase is reached that often completely dominates the time spent writing: revising, revising, and revising some more for absolute precision, accuracy, and often economy of expression [1, pp. 322, 384] [2, p. 91], especially at the subparagraph, individual-sentence, and even word level [3, p. 71]. The cost of such perfectionism is the tremendous time investment associated with any serious writing task.

Writing Style and Emphasis

At this point, none of the following observations about the styles that can be seen in the papers written by NTJ and NTP authors will be terribly surprising.

NTJ writers tend to	*NTP writers tend to*
be specific and detailed on experiments, applications, and examples	give intuitive, "handwaving" descriptions of experiments, applications, and examples
give intuitive, "handwaving" explanations of concepts	give specific, detailed, and rigorous explanations of concepts
write with good large-scale organization and flow	sometimes organize haphazardly on the large scale
sometimes be haphazard and less than precise at the intra-paragraph and sentence level	be precise and fanatically correct in expression at the intra-paragraph and sentence level

You might examine this very paper, for example, to assess whether its authors are more likely NTJ or NTP by considering (1) the nature of the topical material, (2) the style issues tabulated above, and (3) any bias in the NTJ/NTP descriptions that might have crept in from the authors' natural valuation of their own ways of doing things. Engineering journals easily provide other examples of the two styles, but do not dispair when samples of both fail to appear in a single journal, because the two camps often do not even share journals to a significant degree. In the communications area of electrical engineering, for example, the *IEEE Transactions on Information Theory* is almost completely NTP, while the *IEEE Transactions on Communications* leans strongly to NTJ papers.

4 Applying These Ideas

Jung observed that

> each type of thinking shows "the other its least favourable aspect. Introverted thinking then appears as something quite arbitrary while extraverted thiking seems dull and banal. Thus the two orientations are incessantly at war" [1, p. 345]. "There is comething intrinsically irritating about this conflict of attitude, and, at bottom, it is the cause of the most heated and futile scientific discussions" [1, p. 311].

The recognition and understanding of one's own type and the concomitant realization that aspects of one's fight-to-the-death philosophy on scientific research stem from a standard-issue psychological viewpoint is tremendously humbling. Wrongheaded colleagues, students, reviewers and such suddenly appear in a new light, not so much "wrong" after all, but simply with a different intellectual responsibility in the research world. This simple change in perspective may be the most-important benefit of awareness of the work of Jung and others in this area.

But it appears that awareness of these ideas can also suggest natural ways to help students. Three recent applications of these ideas to student's oral and written presentations illustrate.

Hidden Revision Talents in an INTJ Writer. An INTJ graduate student with major difficulties being precise in his written arguments and mathematics, especially about the basic strategies behind his research, found tremendous benefit in the suggestion that he experiment with revising that material as if it were for an oral presentation to a roomful of people. This stylistically suboptimum approach made a dramatic difference in the clarity of his expression, and he can refine his style later. The idea behind the suggestion was that being drawn into the image of a roomful of people as an immediate audience might help him retreat from his intuitive word-drafting stage to his extraverted thinking, which he needed for revision.

Audience Contact for an INTP Presenter. An INTP graduate student stared at the feet of his listeners in his oral presentation. He said later that it was because he found that if he looked at the audience, he lost his train of thought. But he subsequently found that he needed less of that introverted thinking function during the talk once he heeded the suggestion that he replace some of the detailed mathematical arguments with simpler, intuitive explanations more naturally suited to presentation by his extraverted side. When he did need the precision of his strongly introverted thinking, he was still able to preserve it while looking at point in the audience midway between faces, giving at least an illusion of audience contact.

Patience with Passing Phases. Sometimes inaction is suggested by these ideas. An INTJ graduate student practicing an oral presentation was looking only at his slides and never towards his audience, displaying none of the enthusiasm and audience contact of his previous presentations. But the tempation to "correct" the student's audience-connection problem was resisted, because the student prepared the slides at the last minute and this particular practice run in fact *was* the initial filling of words into a skeletal structure laid out beforehand in the form of overhead slides. It was natural for that filling in to be handled largely by the student's introverted intuition. Further revision of the talk would presumably bring back the extraverted thinking that usually lent such outgoing sparkle and precision to his presentations.

There is much to be learned here, and we hope you will join us in this exploration of the way extraversion and introversion relate to written and oral presentations in engineering, first by patiently observing until these threads become clearer, and then by gently experimenting with and refining the ideas. There is certainly a snake pit in the potential to be rigid and inflexible, treating preliminary and sketchy ideas as dogma, so we urge patience and skeptical observation, all while adopting the physician's dictum to "do thy patient no harm" in interactions with students and others.

Finally, remember the old joke?

> **There are two kinds of people, those who divide people into two kinds and those who do not.**

With a wink, we ask "Which are the extraverted thinkers and which are the introverted thinkers?"

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