Ambix

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/yamb20

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To cite this article: Armel Cornu (2023) Senses and Utility in the New Chemistry, Ambix, 70:4, 380-398, DOI: 10.1080/00026980.2023.2265681

To link to this article: https://doi.org/10.1080/00026980.2023.2265681

AMBIX, Vol. 70 No. 4, November 2023, 380–398

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Senses and Utility in the New Chemistry

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The New Chemistry, as practised by its early proponents in late eighteenth-century France, is often associated with quantification and a move away from sensorial perceptions. In this paper, I argue that the sensory, far from being discarded by the practitioners of the New Chemistry, thrived in one of their major productions: the *Annales de Chimie*. Viewing the New Chemistry through its relation to the sensory highlights the diversity of chemical applications and offers a new way of examining the connection of chemistry to state and industrial actors. Chemists utilised a precise vocabulary which allowed them to productively interact on the subject of the senses. Sensorial impressions were used for distinct purposes, including the identification of substances, and to track the progress of ongoing chemical transformations. Most important, the senses were frequently tied to the purpose of chemical work. As chemists put their expertise in support of the state, industry, medicine, and commerce, they aimed to improve the sensory qualities of their objects of study, be they dairy products or fabric dyes. Remaining attuned to the senses, therefore, was an essential prerequisite of the New Chemistry's claim to utility.

The sensory holds a controversial place in chemistry. Taste, smell, at times even sight, are often thought to provide individual, changeable, and thus less reliable information than the kind of evidence derived from carefully tuned instruments. But the senses also hold a constant presence in scientific work. The laboratory space itself conjures up strong bodily and sensory experiences which shape the work of practicing chemists. The role of sensory impressions has, however, evolved

DOI 10.1080/00026980.2023.2265681

alongside the discipline. Tasting chemical substances, for instance, a staple of chemical practice for centuries, is banned from most modern laboratories.[1]

A progressist interpretation would posit that the use of sensory impressions was slowly phased out of chemistry as a function of modernising the discipline. Innovation in both instrumentation and theoretical frameworks could be given as the reason for making chemistry less reliant on impressions of the body. But chemistry is also a diverse and practical field, and chemists have long applied their trade to a variety of questions that necessitate the continued use of the senses. As recent works have shown, sensory practices found a place in the modern laboratory, suggesting that the relationship between chemistry and the sensorial might be more complex than at first glance.[2] Looking at the history of chemistry through an embodied or sensory lens may provide a counternarrative to the story of sensorial disappearance. But if the senses have in fact played an important role in the practice of chemistry, what purposes did they serve?

In this paper, I reconsider the role of the senses in the chemical practice of late eighteenth-century France, the supposed moment of divergence between quantitative, instrument-based chemistry and sensory practices. I argue that this period, referred to as the New Chemistry, was far from a harbinger of imminent sensorial disappearance.[3] Rather, the use of sensory impressions was both frequent and relatively uncontroversial throughout different branches of chemical practice. The senses were not unreliable indicators to be avoided, but instead a necessary part of the everyday conduct and public perception of chemistry. In fact, the ability of chemists to work with the sensory qualities of their objects of study became a central argument in advocating for the utility of chemistry in support of the state, industry, and society.

Studying early modern chemistry through the senses highlights the diversity of practices existing under the umbrella of the New Chemistry and brings a novel way of looking at the connections between chemistry and questions of public interest. However, investigating the role of fleeting sensory experiences in historical contexts poses constant challenges of interpretation. The impressions of those

[1] The practice, however, endured well into the twentieth century. See: Anders Lundgren, "Kemi, pedagogik och lite estetik: Om sinneskunskap i naturvetenskaplig undervisning och forskning runt sekelskiftet 1900," in *Löftet om lyckan: Estetik, musik och bildning*, ed. Anders Burman, Rebecca Lettevall, and Sven-Eric Liedman (Göteborg: Bokförlaget Daidalos, 2013), 149–68.

[2] For recent research on science and the senses in the modern period, see: Alwin Cubasch and Julia-Katharina Neier (2020), "Negotiating Future Foods: Cultural Practices and Nutritional Knowledge in NASA's Space Food Research Program," in *Proceedings of the Dublin Gastronomy Symposium 2020 – Food and Disruption* (Dublin: Technological University Dublin, 2020), 49–60; Sénia Fedoul and Olivier Jacquet, "Une histoire de la qualité sanitaire des vins. Les règlementations à l'épreuve de l'expertise médicale et des pratiques œnologiques (Fin du XIX^{e} siècle au XXI^{e} siècle)," *Vignes, vin, alimentation, santé* 10 (2019): http://preo.u-bourgogne.fr/territoiresduvin/index.php?id=1754 (accessed 21 September 2023); Nadia Berenstein, "Flavor Added: The Sciences of Flavor and the Industrialization of Taste in America" (Phd thesis, University of Pennsylvania, 2018).

[3] This period, home to a "veritable industry of scholarship," has been revised attentively in past decades. In the present case, I use the term "New Chemistry" in an intentionally narrow and conventional sense, referring to the chemistry advocated and published by the Lavoisiers, their allies at the Arsenal, and some of their international correspondents. Lawrence M. Principe, "A Revolution Nobody Noticed? Changes in Early Eighteenth-century Chymistry," in *New Narratives in Eighteenth-century Chemistry*, ed. Lawrence M. Principe (Dordrecht: Springer, 2007), 1–22 (on 1).

who lived in vastly different cultures and epochs are bound to be partially hidden to us, making it difficult to establish the comparability of sensory impressions.[4] As Werrett puts it: "what color actually meant to early moderns should not be taken for granted."[5] This sentiment applies to other senses as well, each of which is culturally and historically contingent. Nevertheless, the challenges posed by sensorial history also create opportunities for further insight into the variety of practices that defined eighteenth-century chemistry.

The fact that the senses are bound to their historical contexts does not make them a doomed object of study. Rather, they become revelatory of the periods in which they are embedded, a claim which has been the central argument of scholarship coming out of the "Sensory Turn."[6] Corbin's seminal work in this area outlines the complex and non-linear history of the relationship between science and scents, recognising that: "science has oscillated between appreciating and depreciating olfactory phenomena."[7] This approach inspired some historians of chemistry to consider the role of the senses in their work. They identified similar regimes of "appreciating" and "depreciating" the senses within chemistry. The period associated with the New Chemistry thus came to be described as a period of depreciation of the senses in favour of an emphasis on quantification.[8]

While it can be tempting to oppose the rationality of the scales with the changeability of the senses, this comparison represents an unproductive line of enquiry. The claim that the senses were about to disappear from chemical practice (or were present as a lingering remnant of older practices) is inaccurate and reduces the diverse applications and practices of eighteenth-century chemistry to a progressist narrative of modernising science. More important, by believing that chemical practitioners viewed the use of the senses as undesirable, historians miss crucial elements of the conduct of chemistry. Recent scholarship has shown the advantages of studying chemistry through its practical applications and interactions

4 Pamela H. Smith, *From Lived Experience to the Written Word: Reconstructing Practical Knowledge in the Early Modern World* (Chicago, IL: University of Chicago Press, 2022).

5 Simon Werrett, "Fireworks and Color in the Sixteenth and Seventeenth Centuries," *Early Science and Medicine* Special Issue: Early Modern Color Worlds, 20, no. 4/6 (2015): 458–77 (on 477).

6 Sensory Turn scholarship concerned with the eighteenth century has brought a novel view of the Enlightenment, notably through the senses of smell and taste. Emma Spary, *Feeding France: New Sciences of Food* (Cambridge: University of Cambridge Press, 2014); Viktoria von Hoffman, *Goûter le monde, Une histoire culturelle du goût à l'époque moderne* (Bruxelles: Peter Lang, 2013); Emma Spary, *Eating the Enlightenment: Food and the Sciences in Paris* (Chicago, IL: University of Chicago Press, 2012); David Howes and Marc Lalonde, "The History of Sensibilities: Of the Standard of Taste in Mid-eighteenth Century England and the Circulation of Smells in Post-revolutionary France," *Dialectical Anthropology* 16, no. 2 (1991): 125–35; Alain Corbin, *The Foul and the Fragant: Odor and the French Social Imagination* (Cambridge, MA: Harvard University Press, 1986).

7 Corbin, *The Foul and the Fragrant*, 6.

8 A contribution to this view was made by Roberts, who argued for the "death of the sensuous chemist." This perception was reinforced by Bensaude-Vincent, who claimed that although chemists continued to "observe changes in colour, smell […] even taste," this "qualitative data was no longer sufficient to determine the interpretation of the phenomena." Bernadette Bensaude-Vincent, *Matière à penser, Le corps refoulé des chimistes* (Presses universitaires de Paris Nanterre, 1997), 3–4. "les chimistes continuent d'observer les changements de couleur, de sentir, de renifler leurs préparations […] mais ces données qualitatives ne suffisent plus à déterminer l'interprétation du phénomène"; Lissa Roberts, "The Death of the Sensuous Chemist: The 'New' Chemistry and the Transformation of Sensuous Technology," *Studies in History and Philosophy of Science* 26, no. 4 (1995): 503–29.

with its objects of study, gazing beyond the dichotomy between "the work of thoughtful mind and dumb hand."[9] Eddy, Mauskopf, and Newman have described chemistry as "a hybrid of science and technology that engendered a host of instrumental, managerial, and experimental revolutions during the eighteenth and nineteenth centuries."[10] It is within this pluralistic view of late eighteenth-century chemistry that I wish to insert a sensorial approach.

In order to study the New Chemistry through sensorial practices, a few methodological assumptions must first be acknowledged. Following the work of Ahnfelt, Fors and Wendin, as well as some of my previous research, I argue that sensory impressions can be transmitted from one person to the next, with unexpectedly high levels of accuracy.[11] Corbin referred to the "baffling poverty of the language" available to scientists to describe smells, alluding to the difficulties of communicating sensory impressions.[12] I suggest, on the contrary, that a combination of repeated experience and a rich vocabulary did allow chemists to have productive exchanges regarding their sensorial impressions. Additionally, while the question of the senses was of theoretical interest to many thinkers in the eighteenth century, including some chemists, I will not use those reflections as the basis for the present investigation. Rather, I want to investigate the question empirically, aiming to establish not what chemists thought of the senses, but what they reported doing in practice.

In order to tackle the problem at its proverbial source, I will investigate the presence of sensory chemistry in what has been viewed as a symbol of the New Chemistry: the *Annales de Chimie*. The *Annales* are a corpus of periodicals founded in 1789 by central figures of the New Chemistry, such as Antoine-Laurent de Lavoisier (1743–1794), Antoine François de Fourcroy (1755–1809), and Louis-Bernard Guyton de Morveau (1737–1816), among others. Each volume compiled several treatises, memoirs, letters, and presentation transcripts, spanning a variety of topics and written by several different authors. The majority of contributors were French chemists, but the *Annales* also included memoirs translated from other European journals and letters from foreign correspondents. The *Annales* editors claimed to not want to enact any bias – particularly towards those who held different theoretical views – but the *Annales* still reflects the networks of Lavoisier's collaborators at the Arsenal. For this study, I have read and used a selection of contributions published throughout the first twenty volumes of the *Annales*

[9] Lissa Roberts, Peter Dear, and Simon Schaffer, eds., *The Mindful Hand, Inquiry and Invention from the Late Renaissance to Early Industrialisation* (Chicago, IL: University of Chicago Press, 2007), 7. For further development on this, see: Pamela H. Smith, Amy R. W. Meyers, and Harold J. Cook, eds., *Ways of Making and Knowing: The Material Culture of Empirical Knowledge* (Ann Arbor: University of Michigan Press, 2014).

[10] Matthew Daniel Eddy, Seymour H. Mauskopf, and William R. Newman, "An Introduction to Chemical Knowledge in the Early Modern World," *Osiris* 29, no. 1, (2014): 1–15 (on 8).

[11] Nils Otto, Ahnfelt, Hjalmar Fors, and Karin Wendin, "Historical Continuity or Different Sensory Worlds? What We Can Learn about the Sensory Characteristics of Early Modern Pharmaceuticals by Taking Them to a Trained Sensory Panel," *Wissenschaftsgesch* 43 (2020): 412–29; Armel Cornu, *Enlightening Water: Science, Market & Regulation of Mineral Waters in Eighteenth-century France* (Uppsala: Acta Universitatis Upsaliensis, 2022), 292–335.

[12] Corbin, *The Foul and the Fragant*, 6. This idea is also echoed in: Steven Shapin, *Changing Tastes: How Foods Tasted in the Early Modern Period and How They Taste Now*, 14, (Uppsala: Tryck Wikströms, 2011), 9.

(ranging from 1789 to 1797), supplemented by a close reading of volumes 1, 6 and 11 in order to better estimate the presence of the sensory within an entire volume.

Contributors to the *Annales de Chimie* made frequent mention of sensory practices. Since such references are varied and difficult to place under a unified label, I cast a broad net onto the source document as to what might qualify as a sensory experience. Chemists trained their bodies, gestures, and senses through repeated experience and exchange with one another. I chose to consider every deliberate attempt at conveying a bodily experience, by including descriptions of tastes and smells, descriptions of observed changes, as well as control over certain gestures, such as the use of breath to move substances, or the attentive listening to sounds. By subsequently sorting and analysing these hundreds of mobilisations of the body and senses, I was able to identify several themes and purposes associated with the senses which are addressed in the following sections.

In what follows I first discuss the question of the body and who was trusted for the recording of sensorial impressions. I then present the methods that chemists used to express sensory impressions, before investigating the credibility of the senses as an identification method. In the final section, I highlight the frequent instances in which sensorial impressions became the ultimate purpose of chemical work, thus supporting the claim that chemists understood their sensory impressions to be central to their arguments for the utility of their field.

Different sensing bodies in the laboratory

Reporting on sensorial impressions required the presence of a body able to transmit such experiences. In the context of eighteenth-century chemistry, it was not always obvious which body was used. In many cases, chemists did not work alone.[13] They had collaborators, assistants, servants, and occasionally friends and family members who wandered in and out of the laboratory space; all were able to weigh in on sensorial matters by pointing out a pungent smell or providing a second opinion on the colour of a precipitate. The presence of additional people in the laboratory has often been omitted from sources, as the writing and editing of a report was usually done by a single person.[14] At times, chemists reported discussions that took place with their assistants, but their presence mostly went unmentioned.[15] The chemist Westrumb was a notable exception to this traditional omission, as he made frequent allusions to those who came to view his experiments.

[13] See for example the habit of analysts to work in pairs, or the examples of collaboration in public courses. Christine Lehman, "Les multiples facettes des cours de chimie en France au milieu du XVIIIe siècle," *Histoire de l'éducation* 130 (2011): 31–56.

[14] See a description of visible and invisible chemical labour and authorship practices in: Francesca Antonelli, "Becoming Visible: Marie-Anne Paulze-Lavoisier and the Campaign for the 'New Chemistry' (1770s–1790s)," *Ambix* 69, no. 3 (2021): 221–42; Steven Shapin, "The Invisible Technician," *American Scientist* 77, no. 6 (1989): 554–63.

[15] Fourcroy was one such chemist, who sometimes referred to the presence of his student and assistant Vauquelin, crediting him for certain observations. Fourcroy and Vauquelin, "Copie de quelques Découvertes Chimiques Par MM. Fourcroy & Vauquelin," *Annales de Chimie, ou Recueil de Mémoires Concernant la Chimie et les Arts qui en Dépendent* 6 (1790): 177–82 (on 177).

He referred, for instance, to his own, and his co-operators' "great surprise" upon witnessing a spontaneous combustion.[16] In one particularly telling instance, he warned his readers against the dangers of a particular gas, noting: "more than once my co-operators & myself have almost been suffocated, & there is no one in my household who has not felt some pain to the lungs."[17] Evidently, in Westrumb's house, the body of every person living there was mobilised during experiments.

Not all chemical work took place in laboratories. Much of it was conducted in the field where interested parties, workers, and passers-by could offer corroborating sensory impressions. The apothecary Tuckert, while reporting on the manufacturing of certain chemicals, observed workers handling delicate preparations with such vigour that he "worried each time that they might break the vessels."[18] This kind of observation was common in factory settings, as chemists relied on the bodily and sensory knowledge of specialised artisans and workers. The opinion of laypeople was occasionally quoted in reports. Fourcroy studied a substance which bore a close resemblance to cow bile, as evidenced by his own senses as well as those of "several people" whom, upon appraising it for themselves without being told what to expect, promptly "recognised [cow bile] by the colour, the odour, the flavour."[19] In this case, the corroborating opinion of those unnamed "several people" made Fourcroy's interpretation more reliable. In another instance, while reporting to the Academy of Sciences on experiments conducted on dyes, Claude-Louis Berthollet (1748–1822) brought a fabric sample to those in session so they could compare their own impression of the colour with his claims, thus bringing his result out of the laboratory and "under the eyes of the academy."[20]

It should also be noted that human bodies were not the only ones whose sensory impressions were being recorded; various animals were employed in the conduct of experiments. Some were submerged in water to measure oxygenation levels, others forced to consume substances to gauge their toxicity. Chemists used animals in this manner to limit the risks posed to their own bodies. Several authors of the *Annales de Chimie* utilised the bodies of animals in a manner reminiscent of chemical

[16] Westrumb, "Nouvelles Expériences sur la Combustion de différens Corps dans l'acide muriatique déphlogistiqué," *Annales de Chimie* 6 (1790): 240–74 (on 265): "Au grand étonnement de mes coopérateurs & au mien, le charbon de hêtre tout seul s'enflamma aussi."

[17] Westrumb, "Nouvelles Expériences sur la Combustion," 243: "il est nécessaire d'avertir qu'on se tienne en garde de respirer de ce gaz; plus d'une fois mes coopérateurs & moi avons manqué d'être suffoqués, & il n'est peut être personne dans ma maison qui n'en ait éprouvé quelques douleurs dans les poumons."

[18] Tuckert, "Mémoire sur la Fabrication du Sulfure de mercure sublimé (cinnabre du commerce) A Amsterdam," *Annales de Chimie* 4 (1790): 25–30 (on 29): "on remue […] la masse avec un triangle de fer pour en accélérer la sublimation. Les ouvriers s'y prennent avec tant de hardiesse que j'en fus étonné, & que je craignis chaque fois qu'ils n'enfonçassent les vaisseaux."

[19] Fourcroy and Vauquelin, "Copie de quelques Découvertes Chimiques," 182: "un suc si manifestement analogue à la bile de bœuf, que, sans être prévenues, plusieurs personnes l'ont reconnu à la couleur, à l'odeur, à la saveur."

[20] Berthollet, "Mémoire sur l'Action que l'Acide Muriatique oxigéné exerce sur les Parties colorantes," *Annales de Chimie* 6 (1790): 210–40 (on 217): "un jaune pâle, ainsi qu'on peut le voir dans celles que je mets sous les yeux de l'académie."

instruments or indicators.[21] One mentioned the speed at which animals were asphyxiated in nitrogen gas, observing that "they have great trouble to come back," alluding to the practice of attempting to revive the animals after they fell unconscious.[22] Another chemist measured the time it took for birds to be asphyxiated when exposed to sewage, using the results as a way to measure the toxicity of the gas and to emphasise the dangers of such environments. A few paragraphs later, the same author also made mention of the same danger to humans, by relating the accidental death of a worker, who was "struck with death almost in an instant" upon breathing the same fumes.[23]

The death of humans and animals were perhaps the strongest and most unmistakable bodily reactions that could occur in the presence of dangerous substances, and the above examples show that the recording of sensory experiences did not necessarily have to be done by the person writing the report. Sensory experiences could be discussed with others, transmitted, compared, and even inferred from behaviour rather than explicitly described.

From body to text

Following experimentation came the writing of a report, and its subsequent editing in a treatise, memoir, letter, or personal note. While the value indicated on the scales could be easily recorded on paper, sensorial experiments presented challenges when being conveyed into words.[24] Chemists needed to use a precise vocabulary and a variety of rhetorical tools when translating their lived experience into a communicable text.

The body and the senses featured, in some form, throughout most of the contributions to the *Annales de Chimie*. Several chemists devoted a few paragraphs to discussing the training of their bodies, gestures, and senses when conducting chemical work. Special attention was given to the use of air, whether it was moved by the lungs or by bellows.[25] Lavoisier explained for example that there was "an art" to

[21] This was common practice throughout the field. See, for instance, the study on the waters of Bussang which were said to kill crayfish: Lemaire, *Essai Analitique Sur Les Eaux De Bussang* (Remiremont: chez C. Nicolas-Emmanuel Laurent, Imprimeur Ordinaire de la Ville & Marchand Libraire, 1750), 54.

[22] Fourcroy, "Extrait d'un mémoire ayant pour titre, Recherches pour servir à l'histoire du gaz azote ou de la mosette, comme principe des matières animales," *Annales de Chimie* 1 (1789): 40–46 (on 44–45): "Le gaz azote a sur les animaux vivans une action délétère très-énergique; ils y sont asphixiés avec une promptitude étonnante, & ils ont beaucoup de peine à revenir."

[23] "Rapport sur des Pompes Anti-Méphitiques," *Annales de Chimie* 6 (1790): 86–120 (on 106, 108): "Des oiseaux […] y ont été asphixiés en moins de cinq minutes," "c'est en enlevant le pavé […] que l'ouvrier est surpris & frappé de mort presque à l'instant."

[24] On this, see: Smith, *From Lived Experience to the Written Word*.

[25] Numerous contributions highlight this. See: "Procédé de MM. Ruprecht & Tondy, pour réduire les Mines de Tungstène & de Molybdène," *Annales de Chimie* 8 (1791): 3–9 (on 6–7); Adet, "Extrait d'un mémoire sur le Muriate fumant d'étain, ou liqueur fumante de Libavius," *Annales de Chimie* 1 (1789): 5–18 (on 8): "J'introduisis dans la première de l'air de mes poumons; il se forma des cristaux sur les parois internes de la cloche;" Fourcroy, "Extrait d'un mémoire Sur la nature du Vin lithargiré ou altéré par le plomb, & sur quelques moyens nouveaux d'y reconnoître la présence de ce métal," *Annales de Chimie* 1 (1789): 73–80 (on 78):

> Si l'on ramasse avec soin ces précipités, & si on les chauffe avec précaution sur un charbon au chalumeau, ils fument, blanchissent, […] en cessant de souffler à cette époque, on obtient les globules sur le charbon, il faut pour cela que le charbon soit bien solide & non-fendillé, & que l'on ne souffle pas trop fortement.

moving liquids using suction, one which required both precise technique and practice.[26] In a different report, Martin Heinrich Klaproth (1743–1817) recommended that chemists be mindful of their breathing, as the antimony powder he obtained was so fine that it would "disappear with the first breath."[27] Tasting substances also required attention. Jean-Antoine Chaptal (1756–1832) referred to the habit of tasting earths to identify them, a practice that differentiated the senses of the specialist from those of laypeople.[28] The eye was also subject to training. Noticing subtle changes in height or colour was a dominant part of the practice of chemistry.[29] But even with training, errors could be made. Andrea Savaresi (1762–1810) acknowledged for instance that: "our eyes, despite being trained in this kind of observation, have not preserved us from error."[30] Like most chemists, Savaresi knew that the senses could be deceived, but this did not lead him to omit them in his reports.

All senses were mobilised, but sight was by far the most frequently used. There are very few memoirs in the *Annales* that make no mention of changes in colour, sheen, or the overall appearance of substances. The mention of other senses depended on the kind of experiment being conducted. In the analyses of consumable goods for example, taste and smell were unavoidable. Touch was similarly mentioned when relevant. Some products were easier to describe through their viscosity, oiliness, or capacity to be broken with the fingers. Lastly, hearing was least often solicited, though there are examples of chemists mentioning sounds such as the noise of air suddenly leaving a container.[31] Many descriptions could be succinct – at most a few words – others were more detailed. A typical sensory description could read: "[These crystals] are transparent, white in colour, not deliquescent to the air nor sensibly efflorescent: by tasting we can discover something nauseating [and] bitter, accompanied by a sharp acidity."[32]

[26] Lavoisier, "Mémoire sur la combustion du Fer," *Annales de Chimie* 1 (1789): 19–30 (on 21):

> On se sert de ce siphon pour pomper, en suçant avec la bouche, une partie de l'air contenu sous la cloche, & on élève ainsi le mercure. Il y a un art pour élever ainsi en suçant, le mercure sous la cloche; si on se contentoit d'aspirer l'air avec le poumon, on n'atteindroit qu'à une très-médiocre élévation, […] tandis que par l'action des muscles de la bouche, on élève sans se fatiguer.

[27] Klaproth, "Extrait du journal de Crell de 1789," *Annales de Chimie* 6 (1790): 1–50 (on 4): "poussière blanchâtre antimoniale si légère, qu'elle disparoît au moindre souffle."

[28] Chaptal, "Vues Générales sur la formalion du Salpêtre et sur l'établissement des Nitrières artificielles," *Annales de Chimie* 20 (1797): 308–54 (on 323): "on observe ordinairement que ses effloresccnces sont du sulfate de soude ou de magnésie, qui en impose aux personnes peu exercées dans la dégustation des terres."

[29] Research on the role of sight in early modern science has been extensive. To cite two influential works: Alina Payne, ed., *Vision and its Instruments, Art, Science, and Technology in Early Modern Europe* (University Park, PA: Pennsylvanic University Press, 2015); Lorraine Daston and Peter Galison, *Objectivity* (Princeton, NJ: Zone Books, 2010).

[30] Savaresi, "Suite du Mémoire sur la prétendue Métallisation des terres," *Annales de Chimie* ed. Morveau, 11 1791): 38–63 (on 62): "Ce verre avoit extérieurement une teinte grise luisante & d'un brillant métallique de fer si évident, que nos yeux, tout exercés qu'ils étoient à ce genre d'observation, ne nous avoient point préservés de l'erreur de prendre ces globules pour du métal."

[31] One chemist talked about "the sound, similar to that of a red hot iron plunged into water." See Fourcroy, "Observation Sur la Formation de l'Acide nitrique qui a lieu pendant la décomposition réciproque de l'oxide de mercure & de l'ammoniaque," *Annales de Chimie* 6 (1790): 293–300 (on 296) : "le bruit, semblable à celui d'un fer rouge qu'on plonge dans l'eau, a eu lieu."

[32] Hielm, "Essai sur un sel tiré du jus de cerise," *Annales de Chimie* 3 (1789): 29–46 (on 30–31): "[Ces cristaux] étoit transparens, de couleur blanche, non déliquescens à l'air ni sensiblement efflorescens : on y découvroit au goût quelque chose de nauséabond amer, accompagné d'une acidité piquante."

Chemists used various rhetorical techniques to express what they felt during their work. Many descriptions show an attempt to relate to readers. One chemist, when describing the bubbles that rose to the surface of a liquid, departed from the common descriptor of "small jets," and chose to be more precise: "we can see small bubbles […] elevating themselves if I may use the expression, like a rocket."[33] In a similar metaphor, a contributor to the *Annales* described the bright light he witnessed as looking "shiny & similar to that observed in the stars of Chinese fireworks."[34] Another contributor who wrote about colour used a variety of precise terms, such as "minium red," "vermillion," "carmine red," "crimson," "stonecrop gold" or "a perfect lemon yellow."[35]

The *Annales de Chimie* compiled different kinds of chemical texts. Because of this, some were meant for a learned public, others less so. Some contributors therefore adapted their use of language. One explained that the change from a yellow to a brown colour was "in vulgar language" described as "scorched."[36] Another compared the colour he obtained as looking "a little bit greener than the green-grey found in shops."[37] A way to relate to a potential non-specialist was to make comparisons to common products. Johann Christian Wieglieb (1732–1800), used comparisons to everyday plants when trying to describe the colour of a substance, noting that it turned "leak green," or "olive-ish."[38] When referring to the lightness and colour of a substance, a contributor compared it to flour.[39] Comparisons to descriptions of taste were also frequent. One contributor recalled that the phosphate of soda had no bitterness, and instead had "a pleasant taste which is very close to that of salt of sorrel that has been boiled."[40]

From the investigation of a sample of the *Annales*, it is apparent that sensory descriptions were ubiquitous, concerned both the use of the body and all five senses, and were generally reported without caveats. Additionally, statements

[33] Adet, "Extrait d'un mémoire sur le Muriate fumant d'étain, ou liqueur fumante de Libavius," *Annales de Chimie* 1 (1789): 5–18 (on 12): "on voit de petites bulles s'élever de dessus sa surface, […] s'élever s'il m'est permis de me servir de cette expression, comme une fusée."

[34] Lavoisier, "Mémoire sur la combustion du Fer," *Annales de Chimie* 1 (1789): 19–30 (on 22): "tout le fer brûle jusqu'au dernier atôme en répandant une lumière blanche, brillante & semblable à celle qu'on observe dans les étoiles d'artifice chinois."

[35] Le Gentil, "Mémoire Sur la couleur qu'affectent les objects peints en rouge ou en jaune lorsqu'on les regarde à travers des verres rouges ou jaunes," *Annales de Chimie* (1789), 10 (1791): 225–54 (on 233): "rouge de minium, de vermillon & de carmin; un autre cramoisi avec de la laque," "un jaune de citron parfait," "orpin doré."

[36] Berthollet, "Mémoire sur l'Action que l'Acide Muriatique," 222: "cette substance devient, selon l'intensité du phénomène, jaune, fauve, brune ; & dans le langage vulgaire, on dit qu'une substance a roussi lorsqu'elle a éprouvé cet effet."

[37] Lavoisier and Berthollet, "Rapport d'un mémoire de M. Chaptal, sur quelques propriétés de l'Acide muriatique oxigéné," *Annales de Chimie* 1 (1789): 69–72 (on 72): "La couleur en est un peu plus verte que celle du verd-de-gris du commerce."

[38] Wiegleb, "Analyse d'une Espèce de Grenat Vert," *Annales de Chimie* 1 (1789): 231–34 (on 231): "Leur couleur est tantôt verd poireau, tantôt olivâtre."

[39] Premier, "Extrait Des douze cahiers des Annales chimiques de Crell, année 1794," *Annales de Chimie* 20 (1797): 383–90 (on 388):"cette espèce de terre, que plusieurs mineralogistes désignent sous le nom de *farine de montagne*, à cause de sa blancheur et de sa grande légèreté."

[40] Hassenfratz, "Extrait du journal de Crell de 1789," 6 (1789): 1–50 (on 9): "Le phosphate de soude n'a pas la moindre amertume, il a au contraire une saveur agréable qui approche beaucoup de celle du sel d'oseille que l'on a fait bouillir."

suggesting that chemists who were guided solely by the taste and smell of substances should be dismissed were virtually non-existent from such reports. Sensory descriptions were a constant source of information, one that most chemists felt the need to relay in their reports regardless of readership.

Identifying and tracking

In chemical reports, the senses were used prominently in relation to specific operations, an important example of which was the identification and differentiation of substances. Taste and smell offered a relatively easy way for the seasoned experimenter to identify products quickly. Like other analytical methods in the eighteenth century, however, the perceived reliability of the senses varied. In some cases, a sensory appraisal was thought to offer only tentative conclusions. In one example, Fourcroy was asked to consult on the unusual case of a patient who cried droplets of blood during crises. Fourcroy claimed to have witnessed one such episode, and though eager to gather the liquid for further analysis, the quantity was so small that he was not able to perform tests. Lacking material, he resorted to a simple visual inspection and noted that the change in colour was likely the sign of Prussiate of iron.[41] In this case, although sight gave him a clue to the composition of the unexplained tears, Fourcroy expressed that it would have been preferrable to conduct a more thorough investigation using reagents and dry analysis. But his disappointment in this instance should not be viewed as an overall dismissal of the senses as an analytical method. In other works, Fourcroy made frequent use of sensory cues to identify substances. He explained for example that animal nitrogen could be recognised thanks to its "particular & distinctive smell," comparing it to the scent that emanated upon throwing "ordinary ammonia on hot coals," a comparison which most chemists reading his work could easily grasp.[42]

In many instances, a sensory impression was used as the sole method of identification. In his memoir on saltpetre, Chaptal described the black earth, and the plants that were needed for its synthesis, explaining that while not all plants were suitable, "poisonous plants, and those that have a strong and stinking smell, seem to be most favourable."[43] The use of sight alone was frequent in mineralogy. Various stones and crystals were identified using a combination of colour, shine, appearance of the cross section, and ability to be reduced in a powder. Chemists sometimes used the naked eye or a magnifying glass to describe the geometry of crystals. Combining these different cues, Klaproth concluded for example that the stone he

[41] Fourcroy, "Observation Sur une singulière altération du Sang par l'effet d'une maladie," *Annales de Chimie* 1 (1789): 65–69 (on 65).

[42] Fourcroy, "Extrait d'un mémoire ayant pour titre, Recherches pour servir à l'histoire du gaz azote ou de la mosette, comme principe des matières animales," *Annales de Chimie* 1 (1789): 40–46 (on 44): "Le gaz azote extrait des matières animales […] a une odeur particulière & distinctive; cette odeur est la même que celle qui s'exhale lorsqu'on jette du muriate ammoniacal ou sel ammoniac ordinaire sur des charbons ardens."

[43] Chaptal, "Vues Générales sur la formalion du Salpêtre et sur l'établissement des Nitrières artificielles," *Annales de Chimie* 20 (1797): 308–54 (on 318).: "les plantes vireuses, et d'une odeur forte et puante, paroissent les plus favorables."

studied was not an emerald, because it had neither "the hardness, the light & brilliant green, nor the crystallisation in hexagonal prisms" of the precious stone.[44]

Some sensory experiences cast doubt on certain interpretations. Richard Walker (1749–1817) expressed being confounded by his observations of water refusing to freeze despite being at very low temperatures, per his instruments.[45] Jean Henri Hassenfratz (1755–1827), during a water analysis, explained that he found it "quite difficult to determine if the hepatic smell of these waters belong to sulphur or to a hepatic gas." He ventured a guess, but since the two substances had very close smells, he could not make a definitive statement.[46] Likewise, Johannes Dollfuss (1729–1800) showed how taste contradicted his initial assumptions. Upon noting that the crystals he handled exploded on hot coals, he assumed they were made of nitre. But since nitre had a known taste which he was familiar with, and the crystals tasted "extremely sharp" and had a "suffocating" smell of acid, he believed the crystals had to be of a different nature.[47]

Chemists were often clear about the value of sensory impressions for the purposes of identification, using words such as "manifestly," "everybody knows," "this fact confirms" or "leads to believe" when referring to the conclusions they drew from sensorial experience.[48] In some cases, the place of sensory information could be simply viewed as a data point within a broader set of observations.[49] The sensory impression was not always sufficient for "decisive proof."[50] But in other

[44] Klaproth, "Analyse Chimique de la Crysolite du Cap de Bonne-Espérance, ou Prehnite," *Annales de Chimie* 1 (1789): 201–16 (on 209): "cette pierre n'avoit ni la dureté, ni le vert clair & éclatant, ni la cristallisation en prismes hexagones de l'émeraude." A similar conclusion is reached in: Klaproth, "Analyse Chimique de la Chrysoprase," *Annales de Chimie* 1 (1789): 147–82 (on 173): "Je n'en ai même retiré que fort peu de la terre verte de chrysoprase dont le coup-d'oeil talqueux en promettoit une plus grande quantité."

[45] Walker, "Expériences sur la Production du Froid Artificiel," *Annales de Chimie* 4 (1790): 94–102 (on 100): "je ne savais pas encore, au moment où je l'ai remarqué, dit M. Walker, que l'eau pût se trouver refroidie 22° au-dessous du point de congellation."

[46] Hassenfratz, "Deuxième mémoire sur les Eaux Aérées, Minérales & Thermales du Nivernois," *Annales de Chimie* 1 (1789): 89–97 (on 93–94):

> Il m'a été fort difficile de déterminer si l'odeur hépatique de ces eaux appartenoit au sulfure ou à du gaz hépatique; cependant il m'a semblé qu'elle étoit due à ce dernier, parce qu'une très petite portion de sulfure de chaux ou alkalin mis dans une très-grande quantité d'eau, a conservé son odeur jusqu'à la fin de l'évaporation.

[47] Dollfuss, "Sur quelques Nouveaux Sels Neutres, Formés avec l'acide marin déphlogistiqué, ou muriatique oxigéné," *Annales de Chimie* 1 (1789): 225–30 (on 227):"Quoique ces cristaux détonnassent sur les charbons, ils avoient une saveur très-différente de celle du nitre. Cette saveur étoit extrêmement piquante, & l'odeur de l'acide nitro-muriatique qui étoit presque suffocante, la rendoit encore plus insupportable."

[48] Van Mons, "Extrait d'une Lettre de M. Kasteleyn, A J. B. Van-Mons, Sur la propriété qu'a l'alcool de dissoudre une plus grande quantité d'huiles volatiles à chaud qu'à froid, &c," *Annales de Chimie* 13 (1792): 72–76 (on 73): "Ce fait confirme;" Morveau, "Essai Sur la dilatabilité de l'Air & des Gaz par la chaleur, & la nécessité de la déterminer avec exactitude pour perfectionner la méthode de réduction des volumes de ces fluides aux volumes qu'ils auroient à une température donnée," *Annales de Chimie* 1 (1789): 256–99 (on 274): "manifestement"; Parmentier and Deyeux, "Extrait d'un mémoire de MM. Parmentier et Deyeux sur l'Analyse du Lait," *Annales de Chimie* 6 (1790): 183–97 (on 184): "Tout le monde sait que"; Savaresi, "Suite du Mémoire sur la prétendue Métallisation des terres," *Annales de Chimie* 11 (1791): 38–63 (on 53): "portoient à croire."

[49] Vauquelin, "Analyse Du Salsola Soda de Linneus," *Annales de Chimie* 18 (1793): 65–81 (on 66): "Dans cet état il a une couleur verte jaunâtre, une saveur salée légérement alcaline et une odeur marécageuse. Il verdit la couleur violette et rétablit celle du tournesol rougie par un acide; cette plante est donc alcaline."

[50] Klaproth, "Analyse Chimique de la Chrysoprase," 154: "cette seule circonstance ne peut servir de preuve décisive."

cases, the senses were believed to grant reliable evidence. Fourcroy often used terms that suggested high trust in sensory impressions, stating in a report: "The flavour *proves* that the union of the tarter of lead with vinegar is not solely a dissolution similar to that of salt in water."[51] In another set of experiments conducted with his student, he wrote: "we have recognised in the product, M. Vauquelin & myself, such a strong smell of bitter almonds and of peach tree flowers, that we *could not have doubted* the presence of the prussic acid."[52] So while not infallible, the senses were demonstrably an important tool in the identification of chemical substances.

The *Annales de Chimie* show that despite the strong emphasis on quantification advocated by the proponents of the New Chemistry, not all chemical operations required precise measuring. Tracking the progress of reactions rarely demanded anything that the trained senses could not provide. The contributor Pierre Auguste Adet (1763–1834) frequently used simple visuals in order to follow the course of his experiments. In a report, he described plunging a rod of tin into a liquid, noting changes in appearance over the course of several days. He noted no alterations for the first eight days, but upon adding water, he observed: "I saw a short time after the rod of tin blackening; but I saw nothing which could announce an emission of nitrogen gas."[53] Many similar transformations were described using only visual cues. One analyst noted that the pale green of a solution turned into a blue colour, subsequently changing texture, and becoming "a brown and gelatinous substance."[54] Later, he noted that as the glass cooled, it lost its yellow colour, becoming "opalescent, and of a milk white."[55] Watt likewise described a slow process of evaporation using nothing but visuals: "on the surface a membrane forms which falls at the bottom of the vase after some time; after this yet more membranes form succeeding to one another until the end of the evaporation."[56]

Other senses also came into play to track the progress of experiments. In some cases, chemists noted the presence of a smell as a sign that a reaction was taking

[51] Fourcroy, "Extrait d'un mémoire Sur la nature du Vin," 76: "Cette saveur prouve que l'union du tartrite de plomb avec le vinaigre n'est pas seulement un dissolution semblable à celle du sel dans l'eau" [Emphasis added]. See a similar affirmation in: Girtanner, "Sur la Dissolubilité du Fer dans l'Eau Pure," *Annales de Chimie* 1 (1789): 220–24 (on 221).

[52] Fourcroy and Vauquelin, "Copie de quelques Découvertes Chimiques," 180–81: "nous avons reconnu […] une odeur si forte d'amandes amères ou de fleurs de pêcher, que *nous n'avons pas pu douter* de la présence de l'acide prussique" [Emphasis added].

[53] Adet, "Extrait d'un mémoire sur le Muriate fumant d'étain, ou liqueur fumante de Libavius," *Annales de Chimie* 1 (1789): 5–18 (on 15): "j'y plongeai un barreau d'étain que je luttai bien exactement au goulot du flacon. Il resta huit jours dans la liqueur sans paroître altéré; j'ajoutai alors de l'eau, & je vis peu de temps après le barreau d'étain se noircir."

[54] Klaproth, "Analyse Chimique de la Chrysoprase," 151: "il se précipita un peu d'une substance brunâtre gélatineuse."

[55] Klaproth, "Analyse Chimique de la Crysolite du Cap de Bonne-Espérance, ou Prehnite," *Annales de Chimie* 1 (1789): 201–16 (on 202): "Le bouton vitreux […] perd sa couleur jaune en refroidissant, & devient opalescent, d'un blanc de lait."

[56] Watt, "Propriétés de La Garance de Zélande, de la meilleure espèce," *Annales de Chimie* 4: 105. "il se forme à la surface une membrane qui tombe au fond du vase après quelque tems; après cela il se forme encore de nouvelles membranes qui se succèdent jusqu'à la fin de l'évaporation."

place.[57] Nicolas-Louis Vauquelin (1763–1829) noted a change of taste during analysis, remarking that the flavour was initially "very pleasant" but that it became "bland & nauseous sometime after."[58] Berthollet, for his part, used scents as a comparative method, reporting that upon the addition of acid, two different substances reacted differently, as "the second garners a much stronger smell, & appears to become more volatile."[59] Sounds could also be indicators of ongoing change. One author of a report noted that a "muted sound manifests the sudden passage of the electrical matter through the water."[60] Westrumb similarly used sounds in his explosive experiments, both as an analytical clue and to track the progress of reactions. In one instance, he found the sounds difficult to hear, commenting that he heard muffled explosions, but that such sounds "seem to stem from a sudden heating up during combustion," rather than resulting from other causes.[61] He also used a combination of smell and taste to assess the results of his experiments, noting the large quantity of "vapours of muriatic acid which have a metallic taste," and which also gave off the smell of "burned horn."[62]

The use of sensory impressions throughout the *Annales de Chimie* highlights an important facet of the practice of late eighteenth-century chemistry. While the senses were occasionally deemed to be insufficient when used in isolation, this made them no different from other identification methods of the time. The use of reagents, to name just one method, was both widespread and often criticised for leading to false positives and causing errors in interpretation. But just like reagents, sensory impressions provided valuable information when taken critically and applied to the right processes. Moreover, not all chemical endeavours aimed to analyse and quantify substances. Proving the existence of a reaction was sometimes all that a chemist needed to achieve, and in those processes, sensorial impressions proved both fast and reliable.

Putting the chemist's senses to public use

Pledging to be useful to the public was a common trope within eighteenth-century chemistry. Whether in service of the state, medicine, industry, or the public at large,

[57] Hassenfratz, "Extrait du journal de Crell de 1789," 6: "A peine ce manganèse a-t-il été placé sur du papier à l'air libre, que l'on ressentit dans le laboratoire une forte odeur de gaz hydrogène […] ce régule a continué de s'oxider pendant trois jours & a laissé dégager une odeur d'hydrogène."

[58] Vauquelin, "Analyse de la Casse," *Annales de Chimie* 6 (1790): 275–93 (on 278): "une matière jaunâtre, transparente & d'une saveur fort agréable d'abord, mais fade & nauséeuse quelque tems après."

[59] Berthollet, "Extrait d'un mémoire sur l'acide Prussique," *Annales de Chimie* 1 (1789): 30–39 (on 35): "le second acquiert une odeur beaucoup plus vive, & il paroit être devenu plus volatil."

[60] Sylvestre and Chappe, "Lettre de M. Sylvestre et M. l'Abbé Chappe, A M. de Fourcroy," *Annales de Chimie* 6 (1790): 121–26 (on 124–25): "alors un bruit sourd manifeste le passage subit de la matière électrique à travers l'eau."

[61] Westrumb, "Nouvelles Expériences sur la Combustion," 264: "on croyoit remarquer de foibles détonnations pendant la combustion; mais ces détonnations, ainsi que le bruit, paroissent provenir d'un échauffement subit & de la vaporisation de l'eau plutôt que de toute autre cause."

[62] Westrumb, "Nouvelles Expériences sur la Combustion," 263: "il se dégage une grande quantité de vapeurs acides muriatiques qui ont un goût métallique, & qui, outre l'odeur de l'acide muriatique, en répandent encore une autre fort désagréable & semblable à celle de corne brûlée."

chemists often stressed the applicability of their expertise.[63] The *Annales de Chimie* show that this rhetoric went beyond mere words. Despite a name that hints at theoretical concerns, the *Annales* were frequently concerned with practical questions, ranging over varied topics such as the production of dyes, the whitening of linens, the refinement of sugar, the preparation of glue, the conservation of milk, or the smell of cesspits. In such investigations, the senses were not viewed as one of many experimental tools, or even as a means to track the progress of reactions. Rather, the sensory impression was the point of the investigation itself.

Some contributions emphasised the commercial value of their objects of study. This tendency was notable among chemists concerned with mineralogy. Since the beauty of stones was sought after, aesthetic considerations made their way into many chemical reports. Klaproth, in several contributions to the *Annales,* took care to give thorough descriptions of minerals. He referred for instance to the "beautiful green" of the chrysoprase stone, before describing the appealing speckled appearance of the stone he had found and analysed.[64]

Many of the memoirs touched on the uses of various household products, and proposed ways to improve their sensory qualities.[65] Combining his sensitivity to both texture and smell, Grossart wrote a summary of his attempts to repurpose rubber imported from Brazil. This rubber tended to lose its texture and elasticity when heated, in addition to exuding an "extreme foulness" in the process, an issue that he aimed to remedy by chemical means.[66]

In a taste-based example, a contributor reported on a new medical salt, the phosphate of soda, which could be used as a laxative. The main selling point of the substance was that "it has no bitterness whatsoever, on the contrary it has an agreeable flavour" as opposed to most other such salts which were known to have deeply unpleasant tastes.[67] This taste could then be used by apothecaries to effectively market the salt to their clients. This was not an isolated example of the commercial benefits of sensory qualities. When conducting research on consumable products, many contributors naturally highlighted their impressions of tastes and smells. In a

[63] See Ursula Klein and Emma C. Spary, eds., *Materials and Expertise in Early Modern Europe, between Market and Laboratory* (Chicago, IL: University of Chicago Press, 2010); Jan Golinski, "Utility and Audience in Eighteenth-century Chemistry: Case Studies of William Cullen and Joseph Priestley," *British Journal for the History of Science* 21, no. 1 (1988): 1–31.

[64] "Notice sur la Fouille de la Chrysoprase, & les terres & pierres qui l'accompagnent," *Annales de Chimie* 1 (1789): 142–47 (on 145): "la chrysoprase transparente & d'un beau verd," "elle varie à l'infini pour sa dureté & sa couleur. Souvent plus de mille morceaux, tous plus ou moins poreux, tachés de blanc & fouillés de substances étrangères." See the same tendency in: Klaproth, "Analyse Chimique de la Chrysoprase," 156: "Parmi les différentes variétés de la terre de chrysoprase brute, grasse au toucher & finement micacée, qui accompagne en partie la chrysoprase, je choisis celle qui, par l'uniformité de son vert pomme, me parut la plus pure & la moins mélangée de parties hétérogènes."

[65] Parmentier and Pelletier, "Rapport Fait au Bureau de Consultation, sur la Colle-forte des os proposée par M. Grenet," *Annales de Chimie* 13 (1792): 192–212 (on 192).

[66] Grossart, "Mémoire sur les moyens de faire des instrumens de gomme élastique avec les bouteilles qui nous viennent du Brésil," *Annales de Chimie* 11 (1791): 143–55 (on 144): "une fétidité extreme."

[67] Hassenfratz, "Extrait du journal de Crell de 1789," 9, 10: "Le phosphate de soude n'a pas la moindre amertume, il a au contraire une saveur agréable qui approche beaucoup de celle du sel d'oseille que l'on a fait bouillir," "en aucune manière de la saveur désagréable de tous les autres sels laxatifs."

memoir concerning a specific tea leaf, Adet made explicit comparisons to "the tea with which the Dutch make commerce" and concluded that the two were comparable in both taste and smell, thus endorsing the new leaf as a potential alternative to Dutch-imported tea.[68] Another report presented the extensive study done by Antoine Augustin Parmentier (1737–1813) and Nicolas Deyeux (1745–1837) on the milks of different animals. Throughout the report, the two chemists made frequent comparisons between the tastes and smells of each milk product.[69] The authors specifically pointed out that, since milk was a natural substance, its chemical makeup would never be consistent from one sample to the next. Providing exact measurements would therefore be irrelevant, making it instead more useful to study the composition of milk by means of sensory qualities, that is, through "characteristics that are easy to grasp."[70] In this case, focusing on qualities open to the senses represented both a pragmatic use of the chemist's time, but it was also in line with commercial objectives, such as the attempt to lengthen the time that dairy products could be sold and consumed.

Several authors applied their chemical expertise to improving different aspects of French industry, such as the manufacture of fabrics and dyes. Monge wrote a lengthy memoir on the topic of felt, using almost exclusively his own hands and a magnifying glass to ascertain the nature of the fibre's texture. He compared felt with human hair, noting a texture which was "perceptible to the touch" and the faint sound that was "sensible to the ear."[71] From this sensory-based investigation, he concluded that wool was unsafe for the purpose of wrapping wounds, not because of any "chemical property," but because of the disposition of the strands that made up the fabric.[72]

Berthollet, like several other contributors, invested his chemical talents in supporting the French dyeing industry.[73] When reviewing a piece concerned with fabric whitening, he congratulated the author for having invented a method which could produce white "more esteemed than the most beautiful white that the English could make."[74] Even in unrelated research, Berthollet made passing

[68] Adet, "Extrait de plusieurs lettres de M. Proust a M. D'Arcet," *Annales de Chimie* 6: 195. "on a trouvé dans les environs de Santa-Fé une nouvelle espèce de thé, dont l'infusion ne le cède point pour la saveur & le parfum à celle qu'on prépare avec le thé dont les Hollandois font commerce."

[69] Parmentier and Deyeux, "Extrait d'un mémoire de MM. Parmentier et Deyeux sur l'Analyse du Lait," *Annales de Chimie* 6: 195. "Le sérum de tous les laits varie & par la quantité, & par la saveur."

[70] Parmentier and Deyeux, 6 (1790): 183–97 (on 196–97): "Il paroît plus naturel d'insister sur l'état où se trouvent ces mêmes parties constituantes, […] & dès-lors il doit présenter des caractères faciles à saisir."

[71] Monge, "Observation sur le Mécanisme du Feutrage," *Annales de Chimie* 6 (1790): 300–11 (on 301): "il se produit un frémissement perceptible au tact & qui se manifeste encore par un bruit sensible à l'oreille."

[72] Monge, "Observation sur le Mécanisme du Feutrage," 304: "On voit encore que la qualité malfaisante de la laine pour les plaies n'est occasionnée par aucune propriété chimique, & qu'elle vient uniquement de la conformation de la surface des brins."

[73] Berthollet, "Extrait de l'art de la teinture par le citoyen Berthollet," *Annales de Chimie* 9 (1791): 138–57. See two additional examples in: Hauffman, "Lettre de M. Jean-Michel Hauffman, a M. Berthollet, sur la Théorie de la Teinture, Colmar, ce 10 janvier 1790," *Annales de Chimie* 7 (1790): 237–43; Westring, "Suite du mémoire Sur la propriété tinctoriale des Lichens," *Annales de Chimie* 17 (1793): 67–84.

[74] Berthollet, "Additions a la Description du Blanchiment, &c," *Annales de Chimie* 6 (1790): 204–209 (on 206): "Notre blanc est maintenant plus estimé que le plus beau blanc que fissent les anglois."

mention of dye applications. He suggested for example that the oxide of tin could form "combinations which are very advantageous to the art of dyeing."[75]

Issues of safety were another common concern for authors of the *Annales de Chimie*, showcasing a different approach to the question of utility. One contributor wrote a lengthy report on the controversial use of silver-coated copper pots and pans. As copper was thought to present health risks, the author tested the crockery in various ways to estimate whether it posed a danger to the public. In the end, he noted that although sustained heat tended to affect the pan's shine, this was not a sign that the silver had worn off, and thus presented no danger of contamination.[76] The visual reference was important for users who might see the change in appearance and worry that a chemical change had also occurred.

An especially obvious example of the connection between sensory chemistry and public utility is found in the report following the inspection of a pump used in the safe cleaning of sanitary cesspits. These pumps were built to extract dangerous gases from Parisian cesspits, and a small detachment of chemists was sent to evaluate their effectiveness. The purpose of this inspection was to improve city sanitation, address the accidental deaths of workers who were tasked with cleaning cesspits, and diminish the horrendous smells they exuded throughout the streets. The sensory was, in this case, a central concern, with chemists aiming to "entirely denaturalise the odour."[77] The chemists noted that a simple way of limiting the danger of these pits was to have the foul air be treated with fire. They explained: "the air of the pit, when it has passed through fire, conserves only a smell of volatile sulphuric acid which we know not to present any danger when it is divided in a large mass of air."[78] Though this method addressed the danger, the smell lingered. Entirely containing it was a near-impossible task. The reporters noted: "it is in vain that one can attempt to stop this air from escaping […] the gas is so penetrating, that it passes through seals." In consequence, the unfortunate "infectious odour spreads in the whole neighbourhood."[79] For this inspection, the heightened sensitivity of chemists to subtle changes in smells might not have been needed, but they were entrusted with the task because of their knowledge of how smells were caused,

[75] Berthollet, "Observations sur la Combinaison des oxides métalliques avec les parties astringentes & les parties colorantes des végétaux," *Annales de Chimie* 1: 242. "L'oxide d'étain forme avec les parties colorantes des combinaisons qui sont très-avantageuses dans l'art de la teinture." Berthollet wrote other contributions on dyes which featured in later volumes: Berthollet, "Extrait de l'art de la teinture par le citoyen Berthollet," *Annales de Chimie* 9 (1791): 138–57.

[76] "Rapport sur le Doublage de Cuivre en Argent," *Annales de Chimie* 6 (1790): 132–41 (on 138): "la casserole a rougi obscurément dans cette dernière opération sans qu'il se soit produit d'autre effet que d'en avoir dépoli très-légèrement l'intérieur."

[77] "Rapport sur des Pompes Anti-Méphitiques," *Annales de Chimie* 6 (1790): 86–120 (on 97): "dénaturer entièrement l'odeur."

[78] "Rapport sur des Pompes Anti-Méphitiques," 97: "En effet, l'air de la fosse, quand il a passé par le feu, ne conserve qu'une odeur d'acide sulfureux volatil qu'on sait n'avoir aucun danger lorsqu'il est divisé dans une grande masse d'air."

[79] "Rapport sur des Pompes Anti-Méphitiques," 102: "C'est en vain qu'on chercheroit à empêcher cet air de s'échapper en scellant les ouvertures des siéges avec du plâtre, le gaz qui se dégage est si pénétrant, qu'il se fait jour à travers les scellements […]; l'odeur infecte se répand dans le voisinage."

how they circulated, and, possibly, because of their presumed resiliency to deeply unpleasant sensorial experiences.

Chemists engaging with matters of public health in this manner, and publicising their work in the *Annales,* helped in advocating for the dedication of chemical practitioners to the service of people and the state. Examples could be found of this kind of argument being made explicitly. Fourcroy, when conducting the rather grim task of investigating the state of corpses found in the cemetery of the Innocents in Paris, claimed that it was the duty of his profession to "be specially charged with care and to look after the health of workers."[80] Berthollet expressed similar parallels between sensory chemistry and safety while collaborating with Lavoisier in an attempt to improve the manufacturing of gunpowder. This work clearly involved risks for the chemists themselves – Berthollet recalled an intense explosion that put "Mr Lavoisier in great danger."[81] However, the two chemists also expressed interest in the safety of soldiers who would ultimately be the ones to use the gunpowder. Although Berthollet described a modification that would make manufacturing more affordable, he regrettably admitted that the resulting gunpowder was too fine in texture, which "excited coughing" when handled, putting its users at risk.[82] This particular modification was therefore abandoned.

The language of utility could be found in numerous applications, from small commercial ventures to support for state endeavours. Contributors often explicitly aligned themselves with the interests of the French government and empire.[83] As the *Annales* were published throughout the events of the French revolution, this rhetoric evolved with the new priorities of the Republic. Chaptal explicitly connected chemistry to serving the state in his memoir on saltpetre, which he opened by observing: "The liberated France which regards saltpetre as one of the most precious elements of its freedom […] must seek ways of reanimating this portion of the national industry," a sentiment followed by the recommendation of several easy and sensory-based techniques which could help in its manufacture.[84]

The *Annales* show clear connections between the use of the senses and chemists advocating for the utility of their field. The authors of the memoirs cited here often worked with the sensory qualities of chemical products and processes. Improving taste, neutralising smells, creating softer textures, were all attempts by chemists

[80] Fourcroy, "Mémoire Sur les différens états des Cadavres trouvés dans les fouilles du cimetière des Innocens en 1786 & 1787," *Annales de Chimie* 5 (1790): 154–85 (on 154–55): "[La physique] étoit spécialement chargée du soin de veiller à la santé des travailleurs."

[81] Berthollet, "Observations sur quelques faits que l'on a opposés à la doctrine anti-phlogistique," *Annales de Chimie* 11 (1791): 3–26 (on 24): "l'explosion a été très-vive, & a exposé M. Lavoisier à un grand danger."

[82] Berthollet, "Observations sur quelques faits que l'on a opposés à la doctrine anti-phlogistique," 25. "elle répand dans son explosion une fumée blanche qui excite la toux."

[83] See for example: Prélong, "Mémoire Sur les Iles de Gorée et du Sénégal," *Annales de Chimie* 18 (1793): 241–309; "Trône de la Couture, Précis sur la Canne, Et sur les moyens d'en extraire un Sel essentiel; suivi de plusieurs Mémoires sur le Sucre, sur le Vin de canne, sur l'Indigo, sur les Habitations & sur l'Etat actuel de S. Domingue," *Annales de Chimie* 6 (1790): 51–63.

[84] Chaptal, "Vues Générales sur la formation du Salpêtre et sur l'établissement des Nitrières artificielles," *Annales de Chimie* 20 (1797): 308–54 (on 336): "La France libre qui regarde le salpêtre comme un des élémens les plus précieux de sa liberté […] doit chercher les moyens de ranimer cette portion de l'industrie nationale."

to engage with the sensory world in an attempt to apply chemical knowledge to real-world problems. The frequency of these sensorial applications brings to light an important facet of the New Chemistry. Rather than being viewed solely as a shift in chemical practice characterised by quantification and exact measurements, the ubiquitous presence of the senses throughout the *Annales* suggests that the New Chemistry, though diverse in its aims, was unified by a shared commitment to serving public and state interests.

Conclusion

The clear presence of the sensory throughout the writings of the *Annales de Chimie* underlines the value of conducting targeted investigations of the senses in the history of chemistry. Despite the intuitive difficulty in conveying bodily impressions into texts, chemists did so with seemingly little hesitation. No sense was absent from the reports, and though the eye remained the most used organ, taste, smell, touch, and hearing still featured regularly.

Chemists made clear attempts to be precise in their sensorial descriptions, frequently using comparisons or easily relatable experiences to maximise their chances of being understood by the wider community of savants and beyond. This was not unique to the contributions of the *Annales*. Chemists had been using such devices for much of the early modern period. What is more notable is to see such a strong continuity between those well-established practices in the world of practical chemistry and the works conducted by the quantification-minded advocates of the New Chemistry. This lack of clear repudiation of the sensory suggests that quantitative and sensorial methods may not be as starkly opposed as they have been portrayed.

The senses were used for distinct purposes. First, they helped identify unknown substances. The contributors to the *Annales* often used their sensorial impressions as a component of a wider proof, highlighting the tendency of eighteenth-century chemists to provide evidence for their claims in a layered manner. Sensorial impressions represented an important source of information, one that few chemists wished to abandon. The sensory was, however, more than a simple tool of identification, and the *Annales* show that not all types of chemical work required strict measurement. Chemists relied on their senses to assess the progress of experiments, to signify that something unusual had occurred, or simply as a hint of later things to come.

Finally, the senses were often the reason for chemical work to occur in the first place. The applications of chemistry to various commercial endeavours, industries, and medicine meant that the appearance, taste, smell, and texture of different substances and processes were frequently the very thing that chemists were attempting to address. In such cases, dismissing the body and the role of sensorial experience would erase an essential aspect of the work of chemists, and a large part of their claim to social utility. If chemists were to be trusted to produce softer

fabrics, less smelly streets, cheaper gunpowder, and brighter dyes, their own senses had to be attuned to handle these various tasks.

As the *Annales* clearly display, the chemical field of the late eighteenth century was a decentred and loosely unified field, concerned with a wide variety of scientific questions. The proponents of the New Chemistry, despite strong unifying beliefs and networks, also showcased this inherent diversity. Some chemists put more stock in the information they gleaned from their senses than others. But despite individual differences, there was also a commonality to uses of the sensory. Communicating sensorial impressions in a careful and precise manner was part of the expected conduct of any chemist, and key to the application of chemistry to problems of public utility.

Acknowledgements

I would like to thank my colleagues and the staff at the Science History Institute for their generous feedback and comments on an early version of this paper, as well as the anonymous referees and Partington Prize committee for their invaluable suggestions and support. I also extend my gratitude to the staff of the Othmer Library for their guidance and for providing me access to the physical editions of the *Annales de Chimie*.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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