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Adaptations of Olfactometry and Odour Measurement with COVID-19 Crisis

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The year 2020 was characterised by a worldwide pandemic crisis due to dissemination of a Coronavirus, the SARS-CoV-2 also named COVID-19. Many economic and social domains were impacted by adaptions or restrictions by the objective to limit local dispersion and more global flow of the virus. Without describing all human health effects of this virus, one characteristic is temporary anosmia. In this paper, firstly the physiological impact is synthetized to explain the anosmia. Secondly, because olfactometry need human smell, adaptations of sensorial methods are described. These adapted methods were proposed by laboratories/companies in charge of olfactometry or odour measurement and mainly concern how the distance guarantees between panellists were proposed.

1. Introduction

The aim of this paper is to summarize two aspects of olfactory impact of COVID-19 crisis. The first part concerns the short description of the physiological impact taking into account that many studies are in progress to study mechanisms of action of this virus on sensorial receptors. Then it is just a synthesis of scientific results or hypothesis known at the beginning of year 2021. The second part, more developed, is dedicated to technical measurement of odours. Because olfactometry and sensorial odour measurement are based on direct sniffing with human nose, panellists cannot carry out tests with a mask. It means, by removing the mask, they are not protected during experiments if the area or people around could be contaminated. In order to limit risks, laboratories proposed adaptions of their protocols. By considering health of panellists as a priority, laboratories were able to adapt their equipment and to propose measurements in accordance with standards or reference methods.

2. Physiology and anosmia caused by COVID-19

The global mechanism of olfaction is a result of chemosensation. Even if humans, because of their evolution, are less sensitive and less dependent on chemical signals than many mammals, olfaction is still an important sense for both environmental assessment (potential hazard detection with unknown odour) and wellness or pleasure (perfumes, food…). So, losses of olfaction capacities are impacting strongly quality of life. Such an impact could be limited on time in case of temporary olfactory dysfunction.
Anosmia is one of existing trouble that change day life because it creates a lack of perception of the environment. This anosmia is generally due to infection/irritation of nasal cavity. Many infections can explain such a disorder like cold, flu but also sinus infection, allergic or no-allergic rhinitis, smoking impact…
Of course, the stuffy nose can be a consequence of a mechanical trouble for nasal flow that could be limited by polyps or tumors and then decrease the capability to smell. But, the loss of smell with COVID-19 infection is more complex and more in relation with physiological impacts.
The Figure 1 tries to represent both aspects of olfaction structure: the nasal cavity where airflow is distributed from external atmosphere to olfactory neuroepithelium and neuroanatomic connections of the olfactory nerve that illustrates the complexity of signal treatment. With such a figure, it's easy to understand than a small infection affects normal airflow distribution and the access to epithelium and, that if the epithelium is a gate for a stronger infection, consequences are wider.

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Olfactory perception can be affected by SARS-CoV-2 (COVID-19) infection. If seasonal infections like flu are known to cause temporary anosmia, it seems that COVID-19 has a more complex action. Many studies showed that the virus can affect the olfactory receptor area without major other impact, or that this area could be a gate for infection of other human parts like brain and then creating headaches, memory and concentration problems… The following paragraphs 2.1 and 2.2 describe respectively the classical anosmia with a virus like flu and the complexity of smell alteration with COVID-19. It is important to note that COVID-19 actions are under study and that some results must be considered as hypothesis.

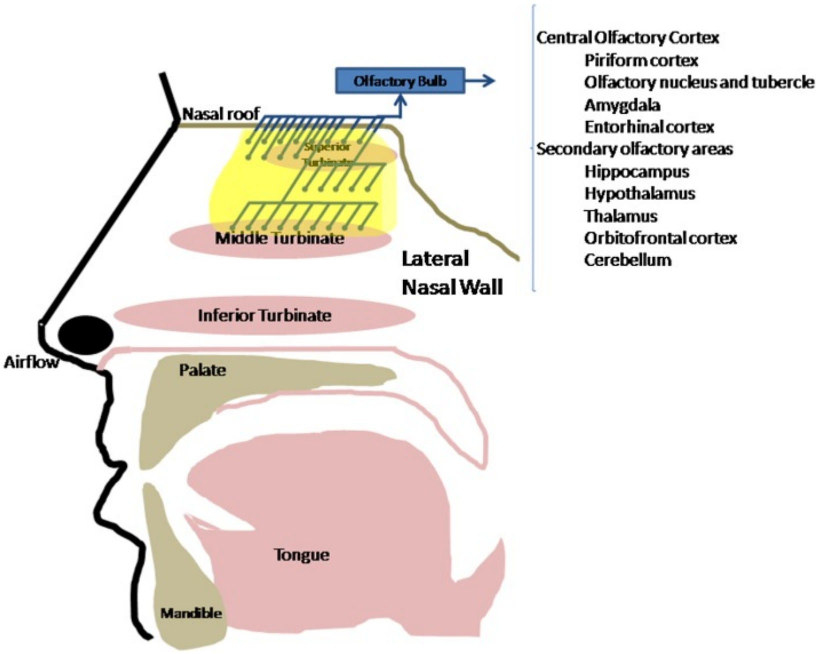

Figure 1: Complexity of olfaction with neuroanatomic connections of the olfactory nerve by Pinto (2011).

Anosmia is not the only dysfunction of olfactory perception and other troubles are also defined (Patel and Pinto, 2014) and listed in Table 1.

Table 1: Other olfactory problems than anosmia

Desease	Dysosmia	Parosmia	Phantosmia
Description	Difficulty to identify an odour	Sensation of a different odour	Sensation of an odour without real presence

If anosmia is a characteristic of some infections, it exists three etiologic categories (Patel and Pinto, 2014). These categories are synthetized in Table 2.

Table 2: Three categories of etiology for anosmia

Problem	Conductive losses	Sensorial (local)	Sensorial (central)
Cause	Obstruction of the nasal way	Olfactory neuroepithelium damage	Central nervous system disease

2.1 Classical anosmia with flu

With a cold or a flue, affected people are often concerned by a temporary anosmia. Such a condition is limited on time, generally few days and not few weeks. The global mechanism is congestion of the nose (stuffy nose and congestion around olfactory epithelium, the location of first smelling action). The presence of viruses in the nose is very common and partially linked to seasonal diseases like flu or cold.

2.2 Anosmia with COVID-19

The mechanism is more complex with COVID-19 and the impact on smelling is clearly different. Firstly, anosmia is one of the main symptom of covid-19 infection. Secondly, anosmia duration is really increased comparatively to a cold. This trouble is observed for few weeks and sometimes up to 2 months or even more. Globally, the come back to normal situation could take long time both for the sensitivity and for quality. With strong olfactory affection, some people must restart learning to be able to characterise and to distinguish odours.
In fact, with COVID-19, it's not just a stuffy nose trouble but a more global impact. The virus attacks the olfactory epithelium in the nasal cavity and the olfactory bulb, but some studies are also focused to understand how the nervous system could also be affected (Reinhard et al., 2020).
With this crisis, the COVID-19 olfactory dysfunction is then an active research domain in terms of physiology and physiopathology. With SARS-CoV-2 infection, potential mechanisms of olfactory disorders are studied and among all studies, potential receptor of the virus are particularly studied like ACE-2 receptors.

3. Technical adaptations for sensorial odour measurement with COVID-19

Three cases of adaptation are described depending on how sensorial odour measurement is carry out. These three sections concern dynamic olfactometry, measurement of intensity and/or quality in laboratories and intensity or sniffing outside.
All the descriptions in paragraphs 3.1 to 3.3 depend on two main parameters:

- Panellists cannot wear a mask for sensorial odour measurement to avoid filtration effect of the mask. Even if masks used for virus trapping do not change the chemical composition of the atmosphere. The mask itself can give a weak odour background incompatible with direct measurement with human nose.
- Without mask, a distance must be kept between panellists or a physical protection must limit air exchange between close people.

3.1 Adaptations for dynamic olfactometry

For measurements by dynamic olfactometry according to EN standard (CEN, EN 13725:2003,), protocol is described about air quality of the room where tests are carried out. This protocol concerns room temperature, humidity level and odourless atmosphere. This last point could be guaranty by filtration of ventilated air on active charcoal, interdiction to enter with odorous materials, perfumes… At all these requirements, COVID crisis implies to be sure that ventilation or air conditioning cannot introduce the virus in the air or typically avoid the diffusion due to air recycling. So at the odourless requirement, the virusless atmosphere is added as objective.
The use of hydro-alcoholic solutions for disinfection must be well defined. Firstly, the solution must be as odourless as possible (some commercial products are odorous), the use on hands of panellists is practiced outside the room for olfactometry and few minutes could be necessary to verify that no residual odour is present.Because panellist could be asymptomatic in terms of olfaction loss, other parameters like fever can be controlled easily before a measurement session in order to eventually exclude panellist with fever.
After considering the environment (room), panellists, a specific attention about the equipment (olfactometer) is necessary. It's obvious to clean parts that be touched by panellists at each session such as buttom to give an answer both for forced choice or Yes/No methods. Independently to cleaning and depending on the structure of the olfactometer and the place, two approaches were developed:

- A panellist has generally a seat quite close to his/her neighbour panellist. The separation plates that isolate panel members around each individual places, are commonly not very large. So the first option was to place larger separation plates (for examples made with polymers such as Plexiglas, polycarbonate…). The objective is simple and based on the principle of isolation of members in a limited area. On the same waaay to increase to distance, an olfactometer with 6 places can be uses with only 4 people and free places in the middle. If this technique must applied for olfactometers with 4 places, it implies to propose 2 identical rounds with each time only 2 panel members. This last description is sample and time consuming
- The second approach was to increase distance between individual sniffing ports of the olfactometer. In that case, it implies to have longer tubing between dilution into the olfactometer and the sniffing port. With this approach, the volume of this new tubing and flow time must be calculated in order to adapt the duration for exposure (stronger volume to flush) and for voting (stronger delay to smell the proposed dilution).

Of course, combinations of these two approaches can be developed but a choice for one option is enough if all rigour around is applied.

3.2 Adaptations for measurement of intensity and/or quality in laboratories

For intensity and/or quality measurements of emitted odour (from food, materials…), it exists a lot of protocols where panel members have to describe the measured parameter. For such a situation, a specific room is dedicated to place panellists in clean and quiet conditions. All aspects about the room that were developed at the beginning of paragraph 3.1 are also available for this kind of measurements. All remarks about panellists are also the same for the period of time before the test like disinfection with hydro-alcoholic solution and potential impact on smelling.
In that case, two aspects must be considered:

- The members cannot smell the same sample placed in the same flask, members after members. It implies to prepare a least as many samples than panellist number. The difficulty is to propose strictly similar samples (weight, size, composition…) in a similar container (flask…). It's easy for homogenous material to be tested but more difficult if not.
- Depending on surface/place into the room, it can be recommended to let just one panel member in the room, then another one… or two members placed at opposite sites into the rooms, then, new members… The method is then adapted depending of the number of members involved in the sniffing test, the initial capacity of the room and the choice of limited capacity (divided by 2 or 3). The examples of capacity evolution into a room is shown in Figure 2. These examples are for 6 panellists that must smell identical samples in a room designed for the odour test. Of course, such an example must be adapted with the room configuration and the total number of panellists for the selected test. The cleaning of the room is carried out after the passage of the 6 panellists. Two main limitations of adaptation must be considered. Firstly, the increase of experimental time because panellists cannot smell strictly at the same time and by limiting the occupation and avoiding meeting of members at the door of the room, the experiment duration is quickly multiplied. Secondly, because it exists a delay between the first member and the last one, the tested product must be stable for such a period. If not, the preparation must be scheduled as a function of sniffing period to let strictly the same delay from conditioning ant sniffing test.

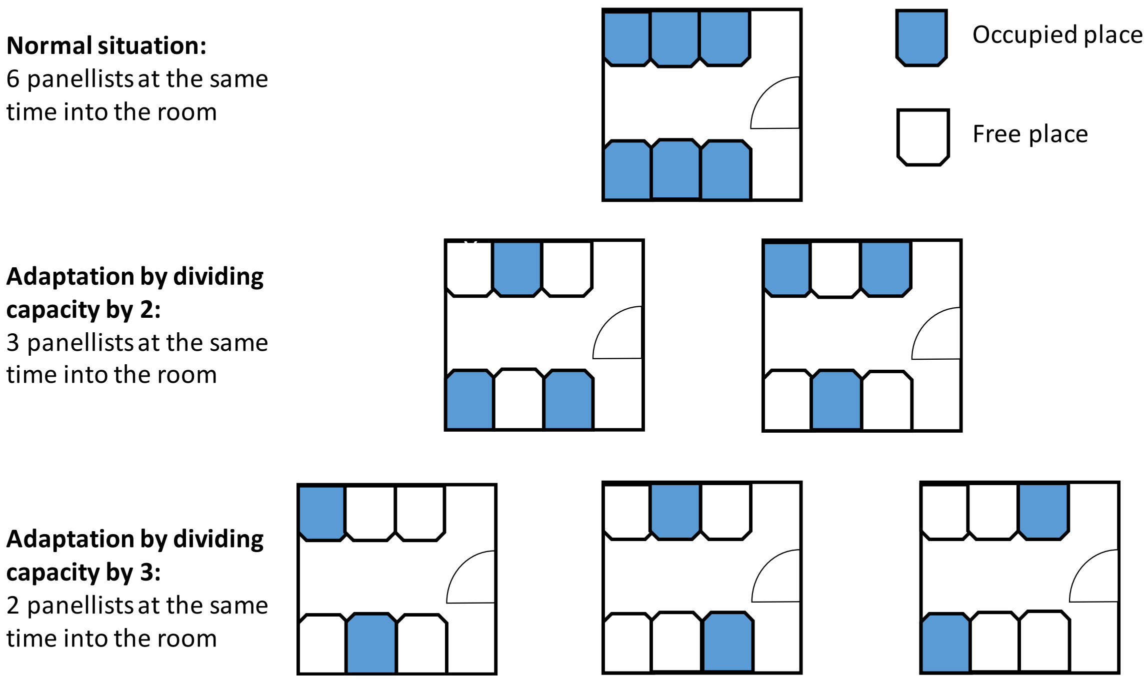

Figure 2: Examples on how to place six panellists as a function of the decided room capacity for measurement of odour quality (Each place is used once by only one panellist and the capacity dividing factor defines the number of consecutive partial tests to reach the global result).

For quality measurements involving a very regular training, the lockdown in many countries was sometimes incompatible with the maintain of such ability as defined by protocols and frequencies or learning/verifications. Then, in some case, it was necessary to verify if trained human noses were efficient enough to distinguish and characterise odours after few weeks without tests. In case of low performance, it was necessary to restart intensive training.

3.3 Adaptations for sensorial measurement outside.

Logically, adaptations for outside are very low comparatively to measurement in a laboratory. So, this paragraph must be considered as more informative than strong adaptations. That is the reason why it concerns mainly recommendations on how to work outside during the pandemic period. For the determination of odour in ambient air by using field inspection, the standards (CEN, EN 16841:2016, part1 and part 2) describe methods to smell alone in the environment.

For the grid method (part1), the panel member is alone on one point. Because he/she is alone, it's possible to smell without mask at the defined point for a 10 minutes duration. Of course, it could be decided by temporal regulation that people must wear a mask and that is forbidden to stay outside due to lockdown or allowed only some parts of the day out of curfew. Depending on the study, it seems possible to be allowed to carry out such an experiment. A limitation could be if the smelling point is placed in a zone where a lot of people are moving like the sidewalk at the crossroads of two streets and then the safety of the panel member could be affected by smelling without mask protection.

For the plume method, if the member is also alone or enough separated on time with others, the experiment can be easily carry out in the countryside. The same restriction than for grid method can be reported: conformity with temporal and exceptional regulation, no possibility to remove the mask in areas with many people around.

After this practical aspect about authorization to remove a mask or not depending on the location, the question of representative activity must be considered because of abnormal situations in some economic sectors. On one hand, it can be considered that such experiments are not representative of real activities when economic sectors are stopped (example: a factory closed) or at an extremely low level of activity (low production and then probably low emissions and low exchanges with transport decrease). But, on the other hand, it's also an opportunity to characterise an area and suspected source impact with a lower air pollution background. In all cases, experiments can be carried out taking into account the representativeness of the period.

The same remarks are available with the use in the environment of direct dilution devices such as "field olfactometers". It is important to note that if such a field device is used in this pandemic period, it's a way to afraid people looking at the panel member. The dilution device could be assimilated, as a filtration system because atmosphere could be potentially hazardous. Unfortunately, this kind of reaction exists even in normal situation when a panellist is observed with a device on her/his face because it's questioning for population. So, in a crisis period with atmospheric contaminants, with unpredictable reactions of people around, the device cannot be used as usual without thinking of potential reactions. In order to avoid panic, the measurement with a "field olfactometer" must be thought depending on the situation and of course with a communication and explanation process to avoid misunderstanding.

4. Conclusions

Since the end of year 2019 and the beginning of year 2020, the COVID-19 caused a worldwide crisis. One human characteristic of this virus is the high capacity to lead to anosmia for few weeks. Unfortunately, stronger impacts on human health with severe respiratory conditions are the worst aspect of this pandemic. With this infection, even if the frequency of anosmia is high, it's not important comparatively to severe case and death rates and long term affections.

Many economic sectors were highly impacted or sometimes totally stopped. The olfactometry and odour measurements were indirectly affected. Of course, variations in the economic sectors influence the activity of laboratories on odours. This variation for the number of odour measurements can change on both directions because less activities leads to a decrease of checks (when its directly linked to the activity) or increase the opportunity to characterize some aspects that are not studied during a full charge of activity and busy periods.

It is a key point to mention that laboratories and companies, where some tests are based on human smelling, demonstrated abilities for adaptations combining quickness, safety and global efficiency. So, of course, COVID-19 crisis had an impact on sensorial odour measurements but the proposed adaptions were efficient to continue experiments in major cases.

Acknowledgments

Laboratories and companies in charge of dynamic olfactometry and/or sensorial measurement based on smelling were reactive to imagine and carry out adaptions compatible with their equipment.

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