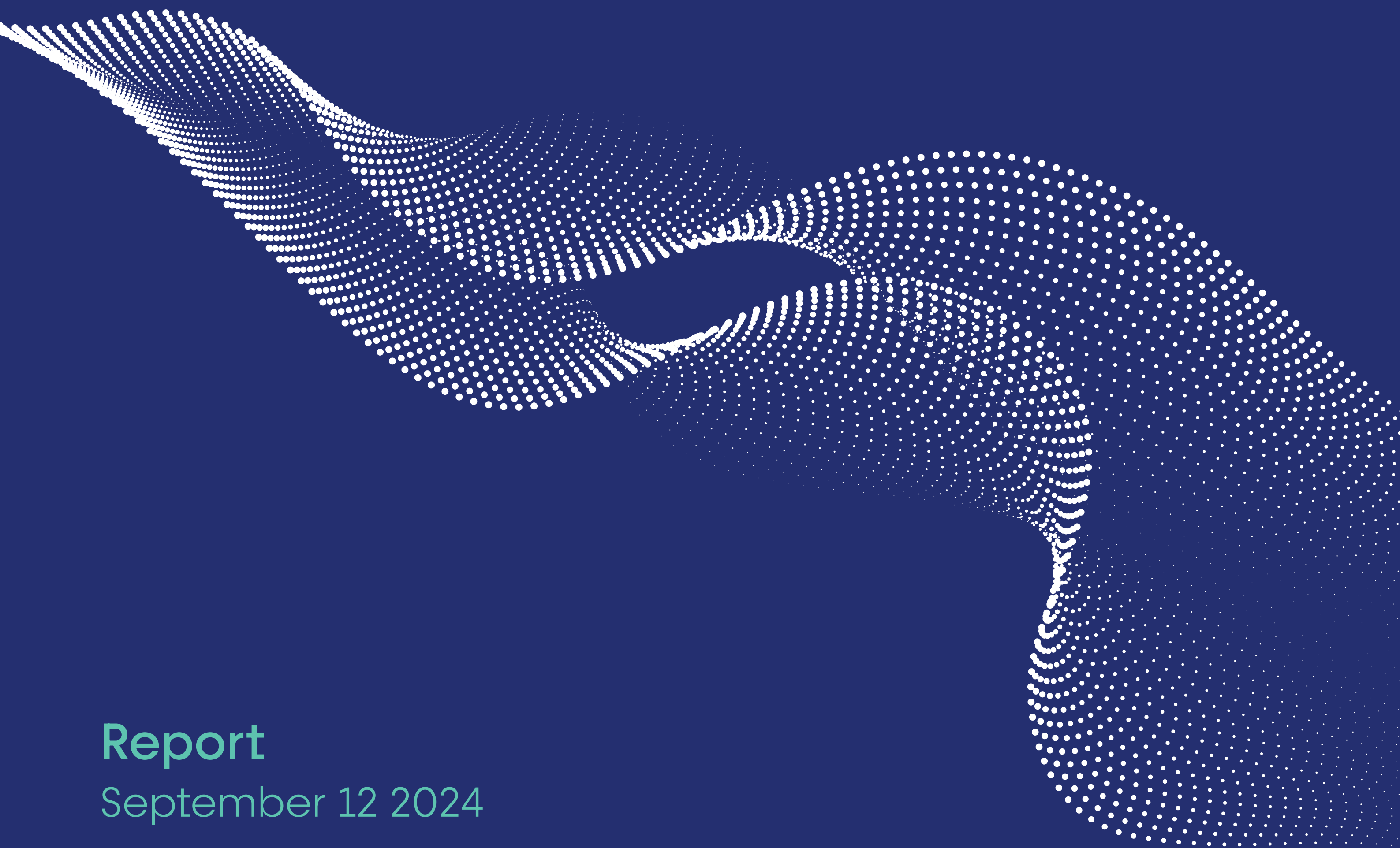
Designing Neuroinclusive Laboratory Environments



Report

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Introduction

Recently, there has been a recognition that neurodiverse employees are often more impacted by their work environment than others and that many workplaces are unintentionally designed in ways which do not support the needs and abilities of neurodiverse employees. This research initiative embeds a multidisciplinary approach to address how the built environment and the sensory elements within it, are impacting individuals that occupy the space, specifically the scientific workplace. The partners on this effort included:

- **HOK Inc.** – a global, design, architecture, engineering, and planning firm, with expertise in designing for neurodiversity including sensory processing and cognitive wellbeing.
- **Advanced Research Clusters (ARC)** – a leading network of science and innovation clusters with expertise in developing scientific spaces in the UK to meet the needs of a new generation of exploratory scientists.
- **Dr. Edward Edgerton**, an environmental psychologist from the University of the West of Scotland (UWS), with expertise in understanding how people understand and experience their work and learning environments and how this is related to design characteristics of these buildings.

Over the past seven years HOK has undertaken continued research on the topic of designing for neurodiversity, sensory processing and cognitive wellbeing. Our team has conducted surveys, focus groups, and research to develop the initial business case, call to action, and design recommendations. During that time ARC, whose network consists of over 300 cutting edge science and tech organisations, has been a leader in developing scientific spaces in the UK to meet the needs of a new generation of exploratory scientists.

To date there has been a dearth of research into creating inclusive scientific spaces, which is why HOK and Advanced Research Clusters (ARC) have teamed up to expand our research into how we design exploratory and scientific lab spaces to be more neuroinclusive for all. To do so, we have consulted with Dr. Edward Edgerton, an environmental psychologist from the University of the West of Scotland (UWS), to aid in analysing the survey findings and facilitate the workshop to enable us to create the inclusive lab of the future.

Environmental psychology is concerned with the systematic study of transactions between individuals and their physical settings. This transactional approach recognises that humans change and modify their environment and that human behaviour and experience are impacted by the environment. If we wish to understand behaviour, we need to situate it in its environment i.e. we need to know where the behaviour is, what the rules of that place are, how they are understood, what people are trying to achieve in that place, and who else is there. This takes us beyond the physical environment to a more complex understanding of environments that brings together many other elements, including social, physical, cultural, and cognitive phenomena.

h+k

ARC Advanced Research Clusters

Given that most people spend a very significant amount of their adult life in work environments of one sort or another, environmental psychologists have conducted a considerable amount of research on workplace environments. Whilst this has covered a diverse range of settings, much of this research has focused on 'white-collar' working environments such as offices. For most organisations, offices and 'office-type' environments are a major investment (second only to employee renumeration) and the design and management of these environments has the potential to impact the company's performance and profitability, along with employee satisfaction and wellbeing.

Environmental psychology research has frequently demonstrated direct causal links between the work environment and employee behaviour and this has ranged from examining individual elements of environmental experience such as lighting, temperature, or noise, to looking at settings from a more holistic perspective. These research findings have been interpreted within major theoretical frameworks such as 'adaptation level theory, behaviour constraint theory and environmental stress, and these theories continue to refine and improve our understanding of people-environment transactions.

The Workplace and Neurodiversity

We all process information differently and our brain functions are unique, hence we are all neurodiverse. Roughly 1 in 5 individuals, neurodivergents, have a naturally occurring variation in neurocognitive functioning, and tend to fall outside of what is considered to be the predominant neurotype. Whilst all brains are different, some people with broadly similar ways of thinking, communicating, and processing information can have a sense of shared identity and experience e.g. an identity such as autistic, dyslexic, or ADHD. People who possess one or more such identities often identify and are referred to as 'neurodivergent' i.e. someone who is not typically referred to as 'neurotypical.'

Often, neurodiverse employees will manage their work environments by hiding signs of their neurodiversity. However, even when their neurodiversity is recognised, their workplaces can still be tiring and exhausting, and impact negatively on their performance and wellbeing. The reality of neurodiversity means that every interaction at work takes place between people with different brains. However, until recently, few organisations thought about neurodiversity within their work environments, especially in relation to the design of workspaces. Given that around 20% of people may identify as having one or more neurodivergent identities, the need to create neuroinclusive work environments is increasingly becoming recognised i.e. consciously and actively designing workspaces to include all types of information processing, learning and communication styles. Recent work in this area has highlighted the importance of reducing sensory stimuli (e.g. replacing bright overhead office lights with desk lamps that mimic natural light), providing quiet areas, and providing assistive technology, such as speech-to-text or text-to-speech software.

The Research Initiative

Successfully creating neuroinclusive workspaces requires a multidisciplinary approach that involves the following elements:

1. identifying and understanding the needs of different employees, particularly those who are neurodivergent,
2. using this knowledge to inform the decision-making process and identify design solutions that create workspaces that accommodate all neurotypes and
3. successfully implementing, managing, and evaluating these workspaces.

The purpose of this project is to explore and better understand how to design laboratory environments to best serve not only neurodiverse populations but to address sensory processing and cognitive wellbeing for all neurotypes. The output from this collaboration is to create an exemplar of inclusive scientific buildings and a guide as to how to achieve them.

Our research was borne out of the notion "nothing about us, without us." The goals of our research were three-fold:

1. Identifying preferences and design elements that impact individuals in scientific spaces.
2. Identifying if the preferences for the individual in scientific spaces vary from the needs in the workplace, and how.
3. Identify design solutions that will aid in the creation of more inclusive and welcoming spaces for a greater percentage of the population.

"If we wish to understand behaviour, we need to situate it in its environment"

Methodology

This project adopted a two-stage approach. In the first stage of the project, an online survey was developed and promoted by the team to lab-based users working on the ARC campuses, science departments at the University of Oxford and participants from selected European science campuses.

Initially 328 respondents agreed to participate in the survey however, only 241 respondents provided usable data.

The second stage involved an in-person design workshop, facilitated by two environmental psychologists from UWS, and was held at the ARC Oxford campus. The workshop was used to establish a set of design principles based on the initial survey results.

Eleven participants took part in the workshop, four of which identified as neurotypical, four identified as neurodivergent and three identified as 'not sure'.

The workshop began with a presentation by UWS and HOK that provided background information about the project along with a summary of demographic information from the survey that was completed in stage one. UWS then conducted a visual enquiry activity where all participants were asked to select an image from a set of cards that "represents how they feel about their workplace environment". Participants were asked to explain their choice of image, and this then facilitated a group discussion about physical and socio-psychological aspects of the workplace environment that were significant to participants.

The second activity in the workshop involved participants rating a set of nineteen images of laboratory-type environments on six dimensions using a 7-point scale; these dimensions were: comfortable, enjoyable, stressful, productive, tiring, and unpleasant. Participants completed this task on their own mobile device using Mentimeter (an interactive presentation software with real-time feedback). The ratings for each image were then presented and participants were asked to comment on aspects of the images that influenced these ratings.

The workshop then arranged participants into three groups for a gaming/zoning activity that was facilitated by HOK. In this task, participants were provided with 2-D kit of laboratory/workplace elements and asked to arrange these into ideal work environment configurations. The workshop concluded with a brief discussion of these plans and the rationale behind the group choices.

328
respondents agreed to participate

241
respondents provided usable data

11
participants took part in the workshop

2024 Scientific Space Research Survey

Mixed Neurotype Scientific Population
February – April 2024

Most research to date on neurodiverse individuals has focused on the young and historically, women have been under represented.*

This survey was labelled as a "neurodivergent study" which may have influenced who responded.

241
Individual mixed neurotype respondents in scientific settings

Conducted in the UK February - April 2024

All participants work in scientific spaces

50%
Female
5% non-binary

71%
30–60 years old

34%
Hypersensitive to at least one sensory stimuli
**Average is 40%

17%
Hyposensitive to at least one sensory stimuli
**Average is 20%

18.6%
ADHD
**UK Average is 8%

2.4%
Dyspraxia
**UK Average is 8%

20.6%
Dyslexia
**UK Average is 10%

15%
Comorbidity
More than 1 neurotypes

25.5%
Autism
9% without comorbidities
**UK Average is 1%

Nothing about us, without us.

We did this research to give a voice to neurominorities and have a deeper understanding of their experiences.

* SOURCE: What is Neurodiversity – ADHD Aware; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8961310/ ** https://sensoryintelligence.com/

Survey Findings

29.9% identified as neurotypical

48.1% identified as neurodivergent

19.5% were 'not sure'

The respondents to the survey also fall into the various age categories as noted below in **figure 1**.

The respondents defined their neurotype as noted opposite in **figure 2**. Of these respondents, 72 identified as neurotypical (29.9%), 47 indicated that they were 'not sure' (19.5%), 116 identified as neurodivergent (48.1%) and 6 selected 'prefer not to answer' (2.5%). 48% reported to be neurodivergent – accounting for comorbidities.

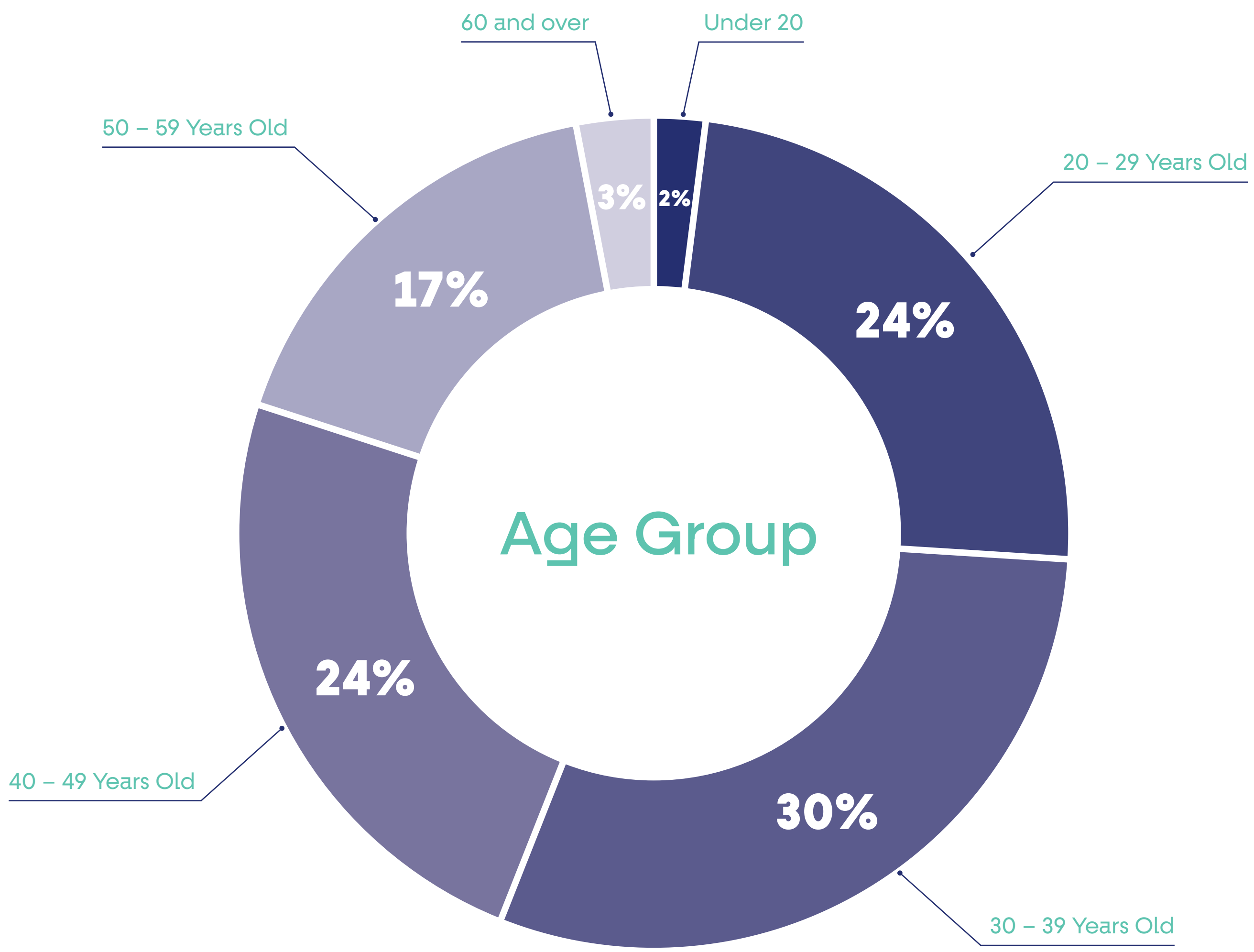


Figure 1: Percentage of respondents by Age Group

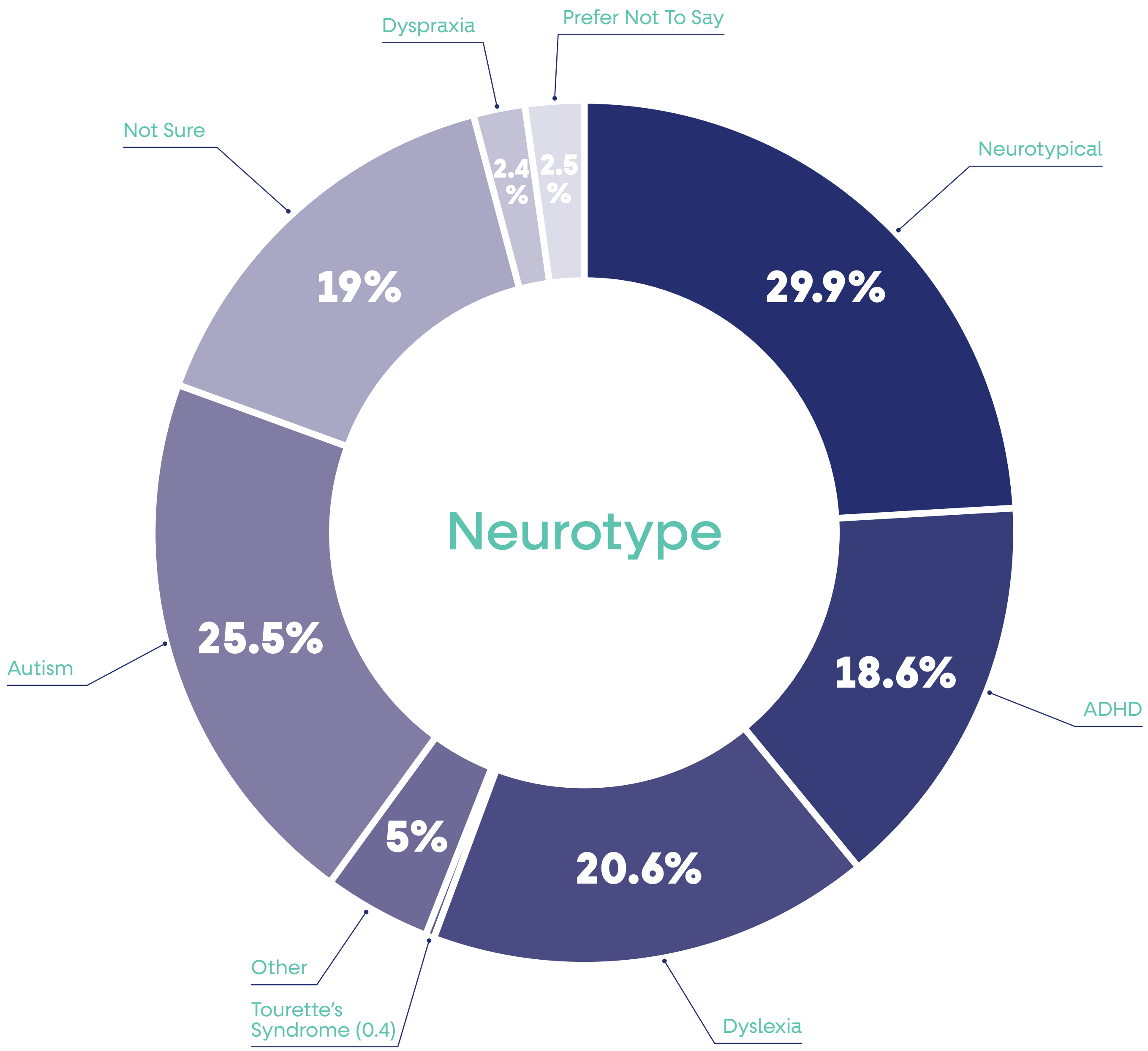


Figure 2: Percentage of respondents by Neurotype

Neurotypical Vs. Neurodivergent

The first set of analyses of the survey data are based on the creation of three different groups of respondents as indicated in figure 3. The neurodivergent group consisted of any individuals that selected one or more of the neurodiversity categories (ASD, ADHD, Dyslexia, Dyspraxia, Tourette Syndrome, other). We can also break down the respondents that noted comorbidities:

Comorbidities

7.9%	ASD + ADHD
2.5%	ASD + Dyslexia
2.1%	ADHD + Dyslexia
8%	Dyslexia + Dyspraxia
.4%	ASD + ADHD + Dyslexia
.4%	ASD + ADHD + Dyslexia + Dyspraxia
.4%	ADHD + Dyspraxia
.4%	Dyspraxia + Tourette

"...it is also essential to understand the different needs and sensitivities within employees that identify as neurodivergent."

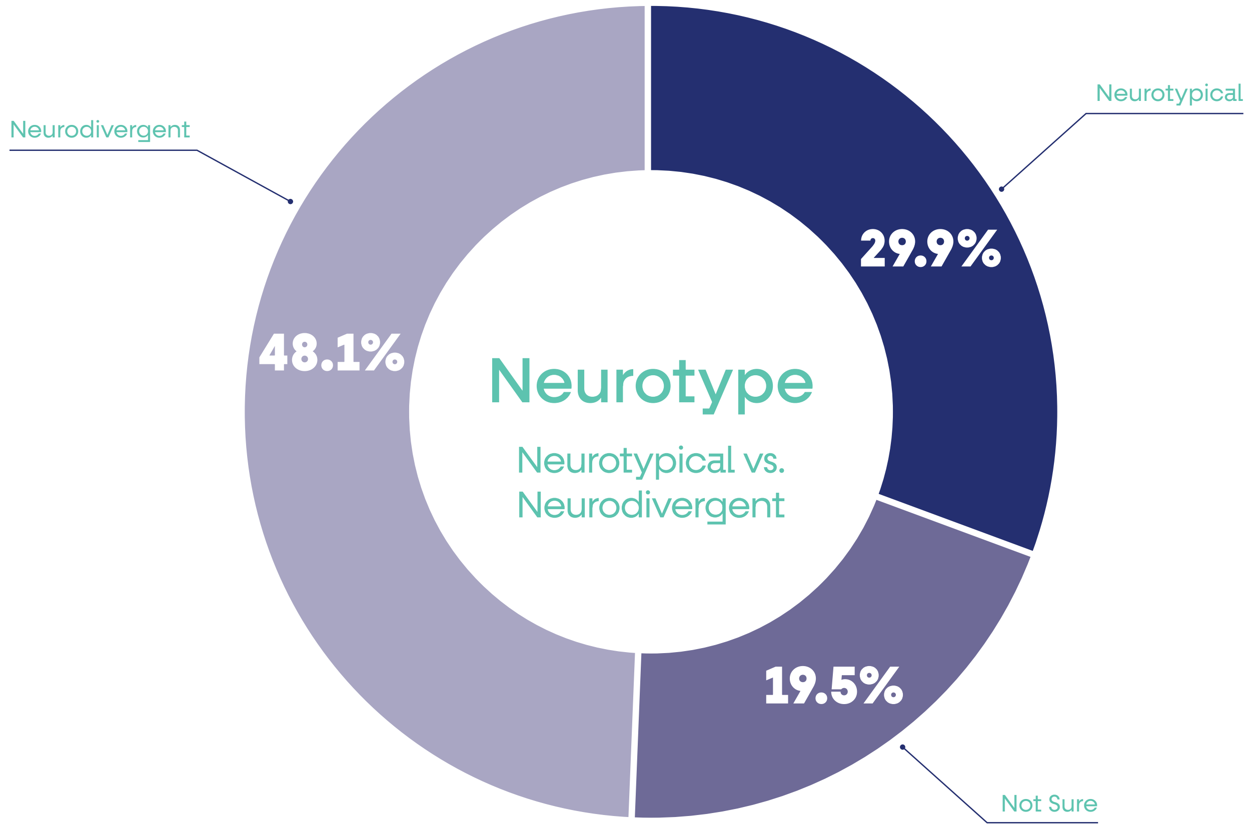


Figure 3: Percentage of respondents that are neurotypical vs. neurodivergent

Only 29% of the younger generation considered themselves to be neurotypical or were 'not sure.'

71% considered themselves to be neurodivergent. Considering that it is widely held that 1 in 5, or 20% of the population is neurodivergent, that's 3.5 times the average.

Is it because:

- this sample pool tended to be more neurodivergent?
- the younger generation is more attuned to their neurotypes?
- neurodiverse conditions were often overlooked and undiagnosed for the older generations?
- there is an increased awareness and diagnosis?
- or perhaps the scientific field attracts more neurodivergents?

Given that research suggests that approximately 20% of people may be neurodivergent, it is interesting to note the high percentage (48.1%) of respondents in this sample that identify as neurodivergent.

Rather than focus on trends and descriptive statistical data, the report will focus on an inferential statistical analysis to identify statistically significant differences between these three groups of respondents in relation to environmental and design aspects of their work environments.

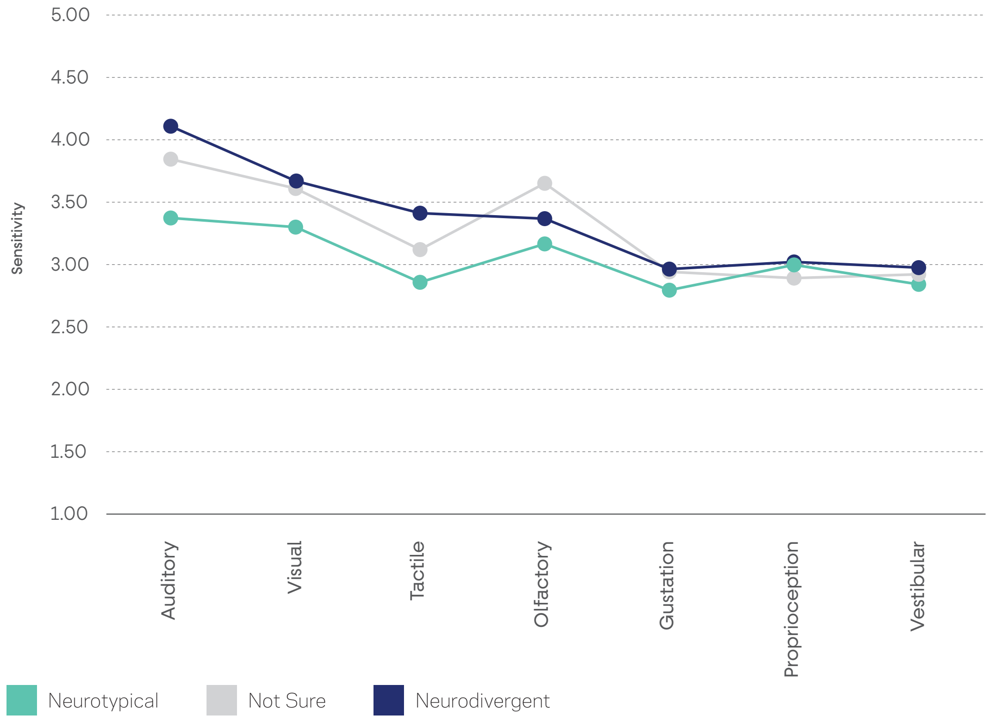


Figure 4: Respondents sensitivity (by neurotype) to environmental stimuli

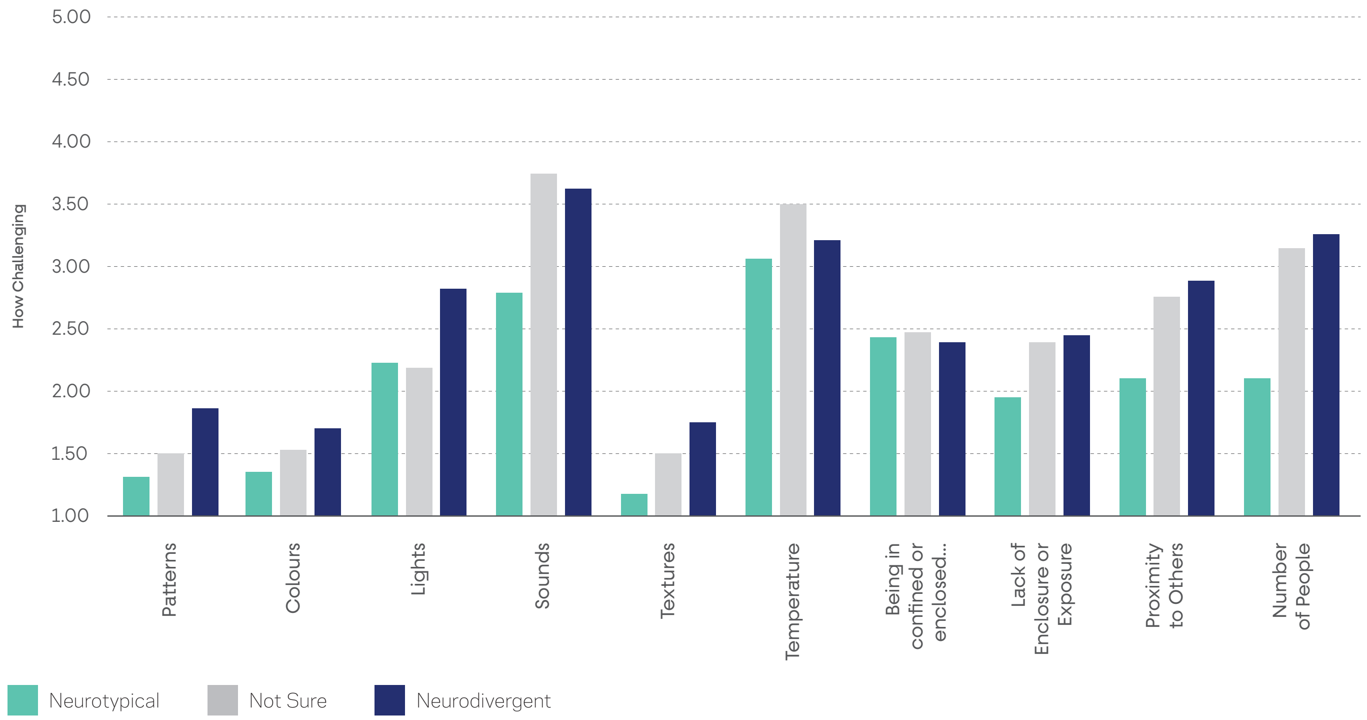


Figure 5: How challenging the different neurotype groups found specific things or elements in their work environment

The first analyses focused on differences between these three groups on how they typically react to the different environmental stimuli listed in the survey, shown in **figure 4**.

Significant differences were found for three out of the seven environmental stimuli:

1. **auditory stimuli**, with the neurodivergent and 'not sure' neurotype groups indicating that they were significantly more sensitive to auditory stimuli than the neurotypical group,
2. **visual stimuli**, with the neurodivergent group indicating that they were significantly more sensitive to visual stimuli than the neurotypical group, and
3. **tactile stimuli**, with the neurodivergent group indicating that they were significantly more sensitive to tactile stimuli than the neurotypical group.

The second set of analyses focused on differences between these three groups on how effective they found different design strategies. Previous research by HOK Inc. had identified these as effective design strategies. Across these twenty-five different design strategies, the neurodivergent group found the following design strategies significantly more effective that the neurotypical group:

- Spaces that allow you to move, pace, fidget.
- Work points located in low-traffic areas.
- Spaces that have areas to retreat to for resetting or grounding.
- Spaces that restrict visual connections.
- Areas for drawing/ doodling in collaborative areas.
- Reduce visual clutter.
- Access to stress balls, fidget furniture, or game rooms.

When asked which design strategies are most effective for you, on a scale of 1–10 *(1 being least and 10 being the most)*, the respondents noted the following strategies:

1. Having a dedicated space you are assigned to.
2. Access to natural daylight.
3. Adjustable ergonomic furniture.
4. Work points located in low-traffic areas.
5. Having the option to select where you will work.
6. Spaces that allow you to move, pace, fidget
7. Dedicated quiet rooms.
8. Spaces that incorporate natural elements.
9. Sit-to-stand desk.

The significant between-group differences highlighted above, were particularly strong for 'spaces that allow you to move, pace, fidget' and 'work points located in low-traffic areas.'

The third set of analyses focused on differences between these three groups on how challenging they found specific things or elements in their work environment. Significant differences were found for five out of the ten elements as follows:

1. **Patterns**, with the neurodivergent group finding this significantly more challenging than the neurotypical group,
2. **Sounds**, with the neurodivergent and 'not sure' groups finding this significantly more challenging than the neurotypical group,
3. **Textures**, with the neurodivergent group finding this significantly more challenging than the neurotypical group,
4. **Proximity to others**, with the neurodivergent group finding this significantly more challenging than the neurotypical group, and
5. **Number of people**, with the neurodivergent and 'not sure' groups finding this significantly more challenging than the neurotypical group.

In addition to these significant differences, **figure 5** shows that some elements are generally considered more challenging than others.

Response By Neurotype

The second set of analyses of the survey data are based four groups:

1. The comorbidity group – individuals that identified as having two or more neurodivergent conditions and represented just over a third of all neurodivergent respondents.
2. Autism /ASD
3. ADHD
4. Dyslexia

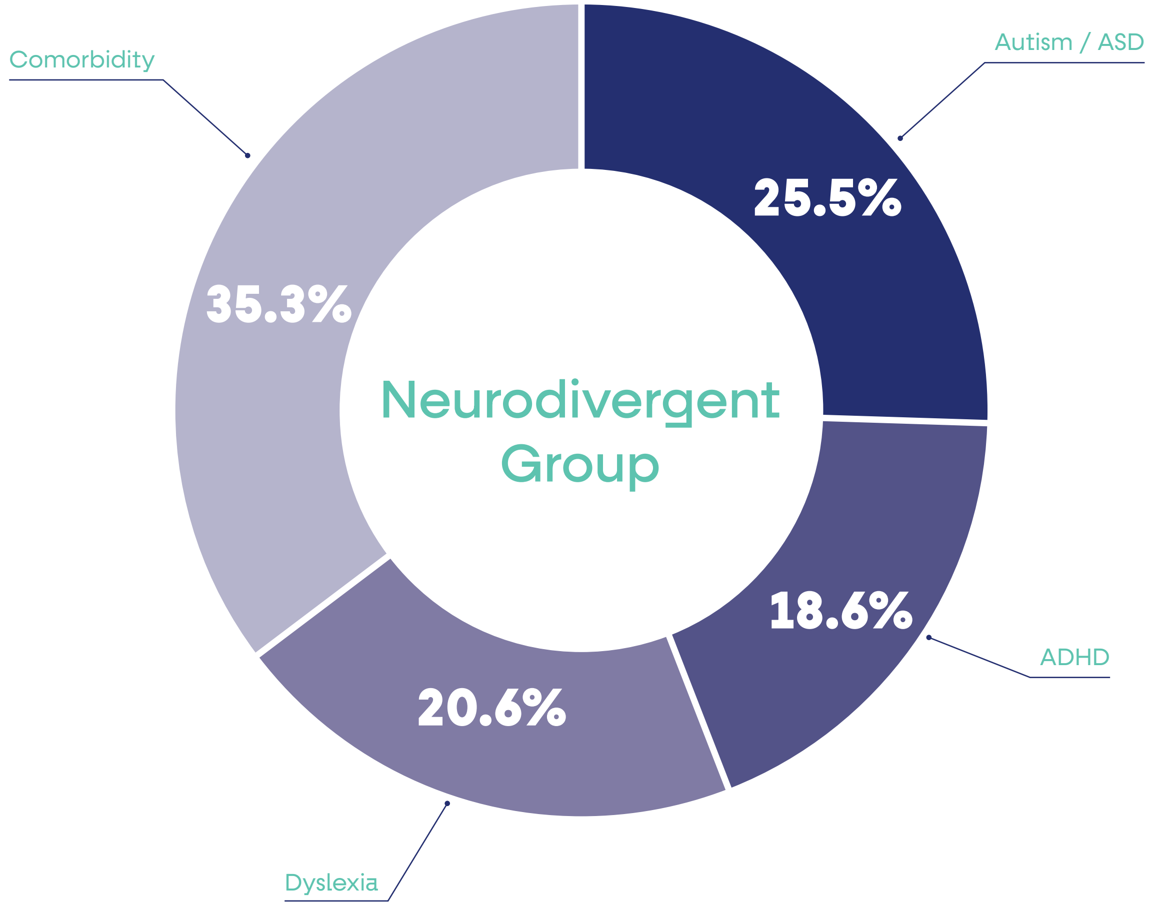


Figure 6: Percentage of respondents by Neurodivergent group

The first set of analyses focused on differences between these four groups on how they typically react to the different environmental stimuli listed in the survey as shown in **figure 7**.

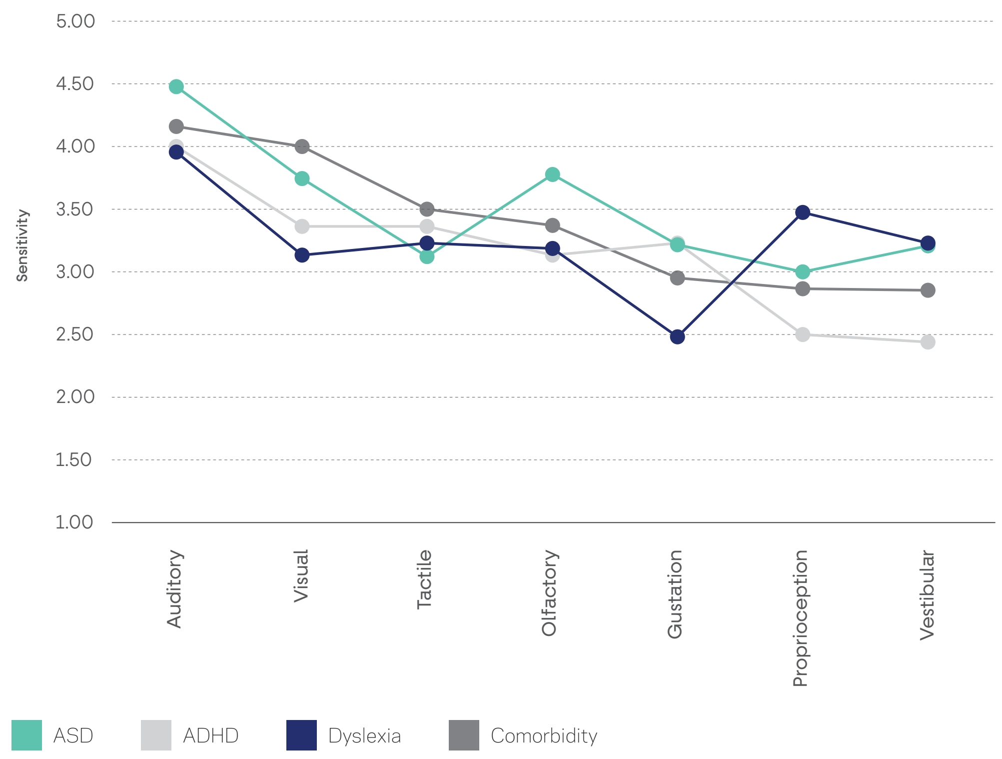


Figure 7: Respondents sensitivity (by neurodivergent group) to environmental stimuli

Significant differences were found for three out of the seven environmental stimuli:

1. **visual stimuli,** with the comorbidity group indicating that they were significantly more sensitive to visual stimuli than the dyslexia group,
2. **proprioceptive stimuli**, with the dyslexia group indicating that they were significantly more sensitive to proprioception stimuli than the ADHD group, and
3. **vestibular stimuli**, with the ASD and dyslexia groups indicating that they were significantly more sensitive to vestibular stimuli than the ADHD group.

The second set of analyses focused on differences between these four groups on how effective they found different design strategies. Across these twenty-five different design strategies, only two showed significant differences between the groups as indicated:

- Spaces that allow you to move, pace, fidget – comorbidity group find this strategy significantly more effective than the ASD group.
- Access to stress balls, fidget furniture, or game rooms – ADHD group find this strategy significantly more effective than the ASD group.

In addition to these significant differences, the data also showed variations in how effective these design strategies were rated. In addition to the significant differences, closer analysis showed that whilst the design strategies of 'having a designated space that you are assigned to' and 'work points located in low traffic areas' are generally considered effective strategies, this is less so for the ADHD group compared to other groups.

The third set of analyses focused on the differences between these four groups on how challenging they found specific things or elements in their work environment. Significant differences were only found for one out of the ten elements (Textures), with the comorbidity group finding this element significantly more challenging than the dyslexia group. In addition to this significant difference, **figure 8** shows that some elements are generally considered more challenging than others.

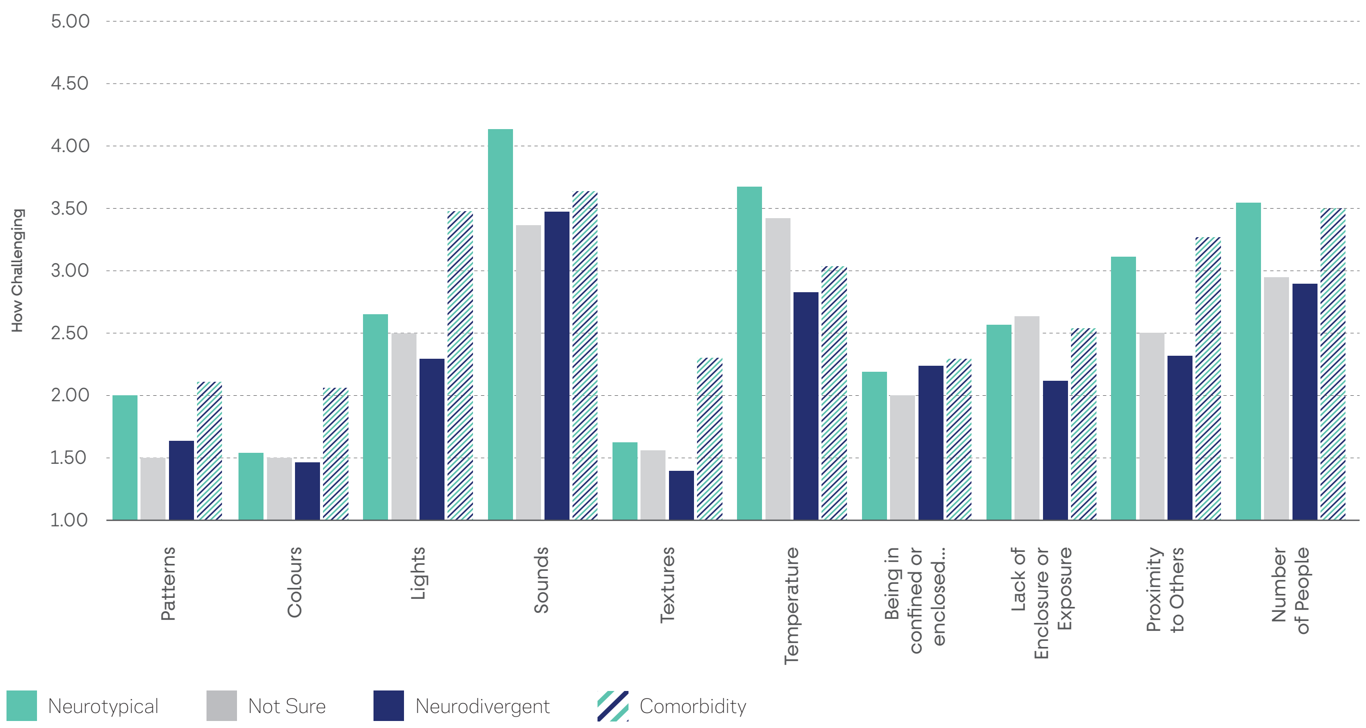


Figure 8: How challenging the different neurodivergent groups found specific things or elements in their work environment

Workshop Findings

The workshop consisted of three main activities and the findings from these are provided below.

Key findings from the activity 1 – Visual Enquiry

A large number of comments were made about space particularly in relation to having a space to retreat to for wellbeing, relaxation, refresh, decompressing etc. this is particularly important where employees spend a lot of time within one space. However, it was recognised that there could be different needs for this space such as a quiet, calming self-care space, a place for relaxing (listening to music) or a space for socialising with others.

A question that was raised in relation to this issue was whether one multi-purpose space could provide choices that could satisfy these different needs. Throughout this discussion the issue of choice was frequently mentioned i.e. being able to choose a space to suit your needs.

For some types of laboratory environments, the practical issue of changing out of lab clothes/equipment was highlighted, and two issues that were raised in relation to this were:

1. whether these break-out spaces should be located within the lab area or outside of the lab area, and
2. the transition from lab space to other spaces such as office space can be overwhelming and associated with sensory overload (better link spaces).

Open plan versus enclosed spaces was mentioned by several participants. Open-plan spaces are associated with being overwhelming, having a lack of control/choice, providing little opportunity for private conversations, and being unable to personalise space when unassigned seating is leveraged. However, they were also recognised as often essential from a practical point of view and are suited to collaborative and team working activities, and when combined with free-choice seating this provides individuals with options and choice including sitting in the same spot.

Comfort was mentioned in relation to:

- auditory stimulation, with some noise types being easier to deal with than others; for example, continuous, white noise was considered less irritating than intermittent, uncontrollable noise,
- density, personal space and proximity of others,
- stimulation levels – colour and patterns can reduce the intensity of some large, white spaces but can result in over-stimulation and need to be carefully thought through in terms of scale, closeness to employee and location (e.g. walls, office furniture, etc.). Natural elements (plants, wood, etc.) were generally considered positively,
- furniture and ergonomic considerations such as adjustable desk heights, chair type, etc.

The way in which work environments are managed and the way in which employees can contribute to, and influence this was frequently mentioned. Decisions about the management of space and where staff are located are rarely based on discussions with staff about their needs or sensitivities and are instead often influenced more by factors such as the importance of technology, budget priorities (specific spaces such as dictation room for dyslexia, rest areas, etc., are often the first to go), changing business needs, corporate image, etc. In general, the consensus was that employees need to adapt to the environment and business needs of the organisation and that the importance of the work environment for employees is less of a concern unless specific issues are raised e.g. window glare on screens. There is little agency provided for employees to come forward about environmental needs.

Key findings from the activity 2 – rating image rating using Mentimeter

Participants were asked to rate 19 images on the following dimensions using a 7-point scale: comfortable, enjoyable, stressful, productive, tiring, unpleasant. Ratings of all images were shown to prompt a discussion about the reasons behind these ratings. The most common issues that emerged from these discussions were:

- Visual access – participants frequently mentioned that the spaces in these images were associated with being exposed, feelings of being observed/on display and that this could be uncomfortable and a distraction (depending on how busy the corridors were). It was also highlighted that this would be dependent on whether they were fully glazed walls and the transparency of the glass; responses were more positive when the labs were not fully glazed walls and when the glass wall was not always transparent e.g. frosted glass at the bottom. Finally, there was a discussion on who these spaces were designed for and often this seemed to be for the benefit of visitors, or the organisation's desire to have 'science on display'.
- Stimulation – there needs to be a balance between unstimulating and overwhelming large, white spaces, and spaces where there was too much stimulation e.g. mural very close to work bench/table', amount of pipework, etc. Most appropriate spaces had a view to nature, appropriate levels of colour (muted solid colours are preferred to heavy patterns), appropriate lighting and natural elements such as wood. However, it was also recognised that personal preferences will often play a part in whether specific design elements are considered enjoyable or distracting.
- Ergonomics – the importance of furniture in terms of size, adjustability, colour etc., was frequently highlighted, along with a strong desire for adequate and accessible storage.
- Control/choice – being able to easily move to different spaces, having a breakout space for different activities e.g. meetings, rest/relaxation was rated positively in specific images.
- Perception of employee – a number of images were associated with a lack of personal space and feelings of being 'a rat in a maze', an Amazon warehouse' and a 'cage'. This gave the impression that the employee is seemingly insignificant. However, it was also recognised that this might be dependent on how much time the individual spends in that space.

Key findings from the activity 3 (2-D gaming/zoning)

Participants were asked to create their ideal workspaces using 2-D elements and then 'present' their reasons for this. The main issues that emerged from this were:

- Provision of an alternative space for reset/relaxation, meetings, write-up, etc. These are required inside labs as well as outside of the lab. and often need to be anonymous to avoid being noticed whilst using the space. Local environmental control is desirable within labs as well as these 'external' spaces. Having a menu of 'buzzy' and 'quiet' spaces was considered essential, whereas uniformity was not desirable. However, having less choice in labs with function-based tasks is recognised and understood.
  - Visual access –

    (i) views out: views of nature from lab space was deemed very positive, but too much glass between labs and general circulation is considered negative due to being distracting. Small areas of glass for view out to internal spaces is good.

    (ii) views in: glass between labs and general circulation considered negative due to being observed, feelings of being on show and a lack of privacy. Overall, participants expressed a dislike of workspaces where they could be viewed (internally or externally) from adjacent spaces or from above; which gave the impression of being looked down upon.
- Level of stimulation, arrangement of space, furniture, etc. is highly dependent on the purpose of that space and the need for specialist equipment. White noise of HVAC can be lived with in labs generally but is problematic when noise goes off or when a scientist steps out of their environment or tries to speak with others.

Designing For Inclusive Spaces

When creating neuroinclusive spaces we start by embracing the principles of universal design that were established to aid creating environments accessible to all.

The seven core principles of universal design include:

1. Equitable use
2. Flexibility
3. Simple and intuitive use
4. Perceptible information
5. Tolerance for error
6. Low physical effort
7. Size and space for approach and use.

"Regardless of neurotype, certain environmental stimuli associated with sounds and temperature can be challenging to most employees."

Design Response

This section summarises how we translated the survey and workshop findings into a design response of key design strategies and requirements. These strategies were then developed into a set of tangible design concepts that were used to transform a typical scientific neighbourhood into a neuroinclusive scientific workplace for tomorrow.

Our overriding goal is to fundamentally address the key challenges of our neurodiverse community and consider *sensory needs holistically* to prevent loss of focus, improve engagement, creativity/innovation, productivity, satisfaction, wellbeing and to reduce stress and burnout within the scientific workplace.

The first step was to analyse the survey findings and workshop comments, to not only create a set of design principles, but to understand the key challenges that face neurodiverse researchers in typical commercial life science laboratory environments.

We started by identifying the core modalities of work that occur in scientific workplaces. Then we overlaid them onto a typical lab layout to uncover gaps for creating diverse types of environments. We believe that a lack of diverse setting and distinct neurozones is at the root of the current lack of satisfaction within lab environments.

"The findings from the workshop complement those from the survey and highlight key environmental characteristics that should be considered when designing neuroinclusive laboratory environments."

Typical Scientific Workplace of Today

The current neurodiversity challenges within typical lab environments:

1. Lacks access to natural daylight
2. Need for cleanliness often equals white, sterile, impersonal spaces
3. Limited or no biophilic elements
4. Noisy equipment
5. Cluttered spaces
6. Limited mobility of occupants as they are often tied to one spot
7. Lack of variety, choice, control
8. No space to retreat to

The generic neighbourhood we have used is a very typical containment level 2 (CL2) commercial life science lab environment in the UK and internationally, with a population of 100 researchers and support staff. It is characterised by contiguous floor plates of c60m long by c26m deep (15-17,000sqft NIA), a 60%/40% lab to write up area split with predominantly open lab configuration with benches on a 3.3m planning module.

Cellular support labs for sensitive processes such as imaging and tissue culture are located at either end of the open contiguous lab spaces. Twin service cores typically located at either end of the neighbourhood consisting of risers, vertical circulation, toilets and stores have not been included to allow a focus on the net usable zones of the scientific workplace.

Typically, the write-up space within the scientific workplace is open with regular rows of desks aligned with the lab planning grid. Cellular meeting rooms are typically added with some informal break out spaces opposite the cores.

The overriding driver for these more uniform lab layouts is to maximise the net to gross area ratio to drive efficiency of space and the greatest density of occupants and bench space within a floorplate. This is understandable given the cost premium of lab buildings over more conventional office buildings. However, as this report outlines, this uniform layout has profound psychological impacts on staff that cannot go unnoticed and can have a negative impact on business success and financial outcomes

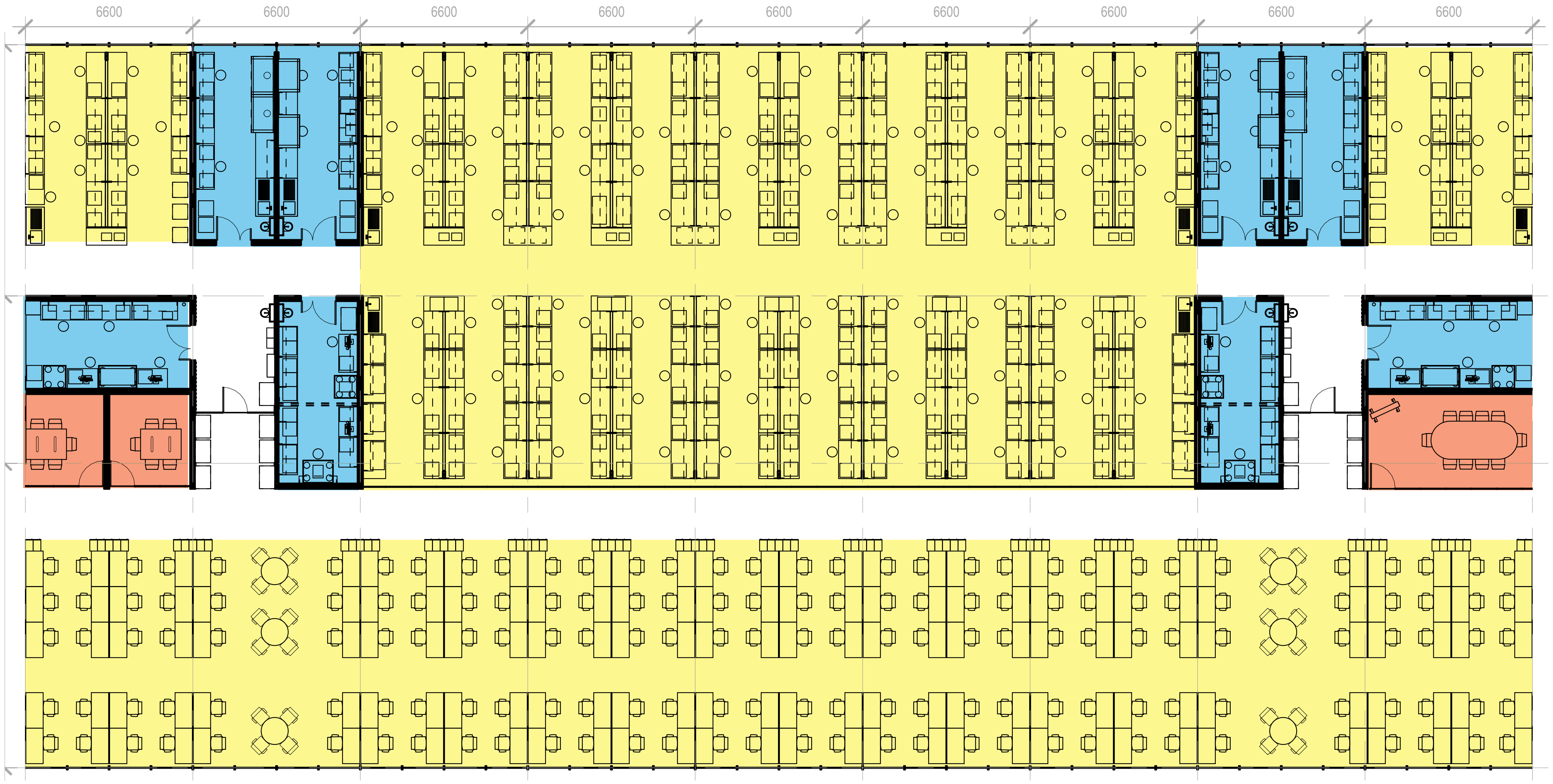


Figure 9: Typical Lab Plan

- Social
- Congregate
- Create
- Commune
- Contemplate
- Concentrate

Neuroinclusive Design Modalities

Working with neurodivergents, environmental psychologists, and neuroinclusive advocates, whilst leveraging our own expertise on the built environment, HOK has developed a unique lens through which to view and analyse space. We start by assessing the tasks that individuals are performing whilst in the workplace, this is called 'modalities of work' or the 6C's:

1. **Concentrate and focus** – deep focus work
2. **Contemplate and refresh** – time alone to reset
3. **Creative work** – innovating or ideating
4. **Congregating, meeting, learning** – meetings, connecting with others
5. **Communal processing** – emails, processing, solo work in a group setting
6. **Convivial or social** – social gatherings, connecting with others.

The diagram opposite (**figure 10**) illustrates the six prime space types and how each type requires different design approaches to accommodate hypersensitive or hyposensitive neurotypes. The diagrams also illustrate typical office workplaces. We have found that all these modes are present within a containment lab environment, but perhaps not to equal degrees. Typically there is more time spent on tasks requiring concentration or communal processing work than contemplation or convivial socialising, However, these lab modes require special spatial, environmental and material considerations to maintain safe and sterile lab environment conditions.

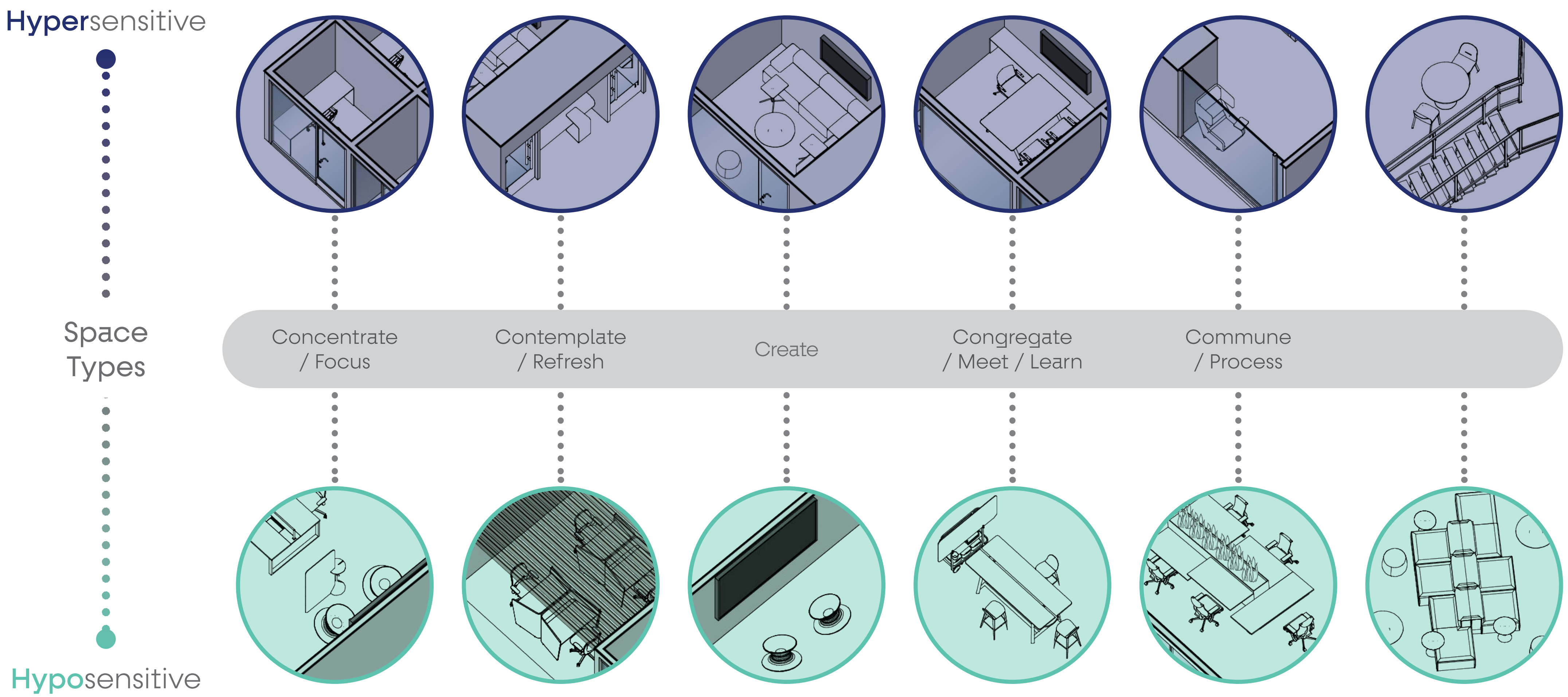


Figure 10: Modalities of work – The 6 C's

As outlined in the survey results analysis, we were particularly interested in which design strategies were considered to be the most effective from the respondent's point of view. The top thirteen strategies (below) were used as the basis for creating more general neuroinclusive scientific workplace design considerations (opposite page). However, rather than prioritising just a few of the design strategies, we believe that a symbiotic range of design strategies are required to ensure the best possible neuroinclusive outcomes. Therefore, we have categorised these as design and management requirements rather than strictly strategies.

Design Considerations

1. Access to natural daylight
2. Option for an assigned and dedicated space
3. Adjustable, ergonomic furniture
4. Option to select where to work
5. Work points in low-traffic areas
6. Spaces that allow for movement and fidgeting
7. Dedicated quiet rooms
8. Screens to block and reduce noise and visual distractions
9. Spaces with adjustable lighting levels
10. Spaces that incorporate natural elements
11. Spaces that have areas to retreat to
12. Display walls for information sharing
13. Accessible storage

Design Considerations

There are a variety of strategies, both operational and environmental, that can make the workplace more inclusive for all. At a minimal level, we recommend you start with some of the basic principles, which include:

Spatial Requirements:

- Provide a range of spaces that allow staff to move easily between lab and write-up
- Allow for collaboration spaces within labs
- Allow for a range of restorative spaces in labs for hyper and hyposensitive researchers
- Allow for a range of hypersensitive retreat spaces and quiet spaces
- Allow for a range of hyposensitive restorative stimulus spaces

Environmental Requirements:

- Allow access to daylighting and views out to nature
- Allow for internal visual transparency but with privacy graphics for the hypersensitive
- Provide local environmental control for neuroinclusivity
- Provide a variety of lighting levels that are suited to the task at hand and enable individuals to adjust them where possible.
- Align the acoustic levels to the spaces, activity and various neurotypes. Leverage acoustic controls – such as absorbent materials and sound masking – to provide acoustic comfort
- Reduce visual clutter within spaces and ensure clear lines of sight for ease of orientation and navigation

Materiality Requirements:

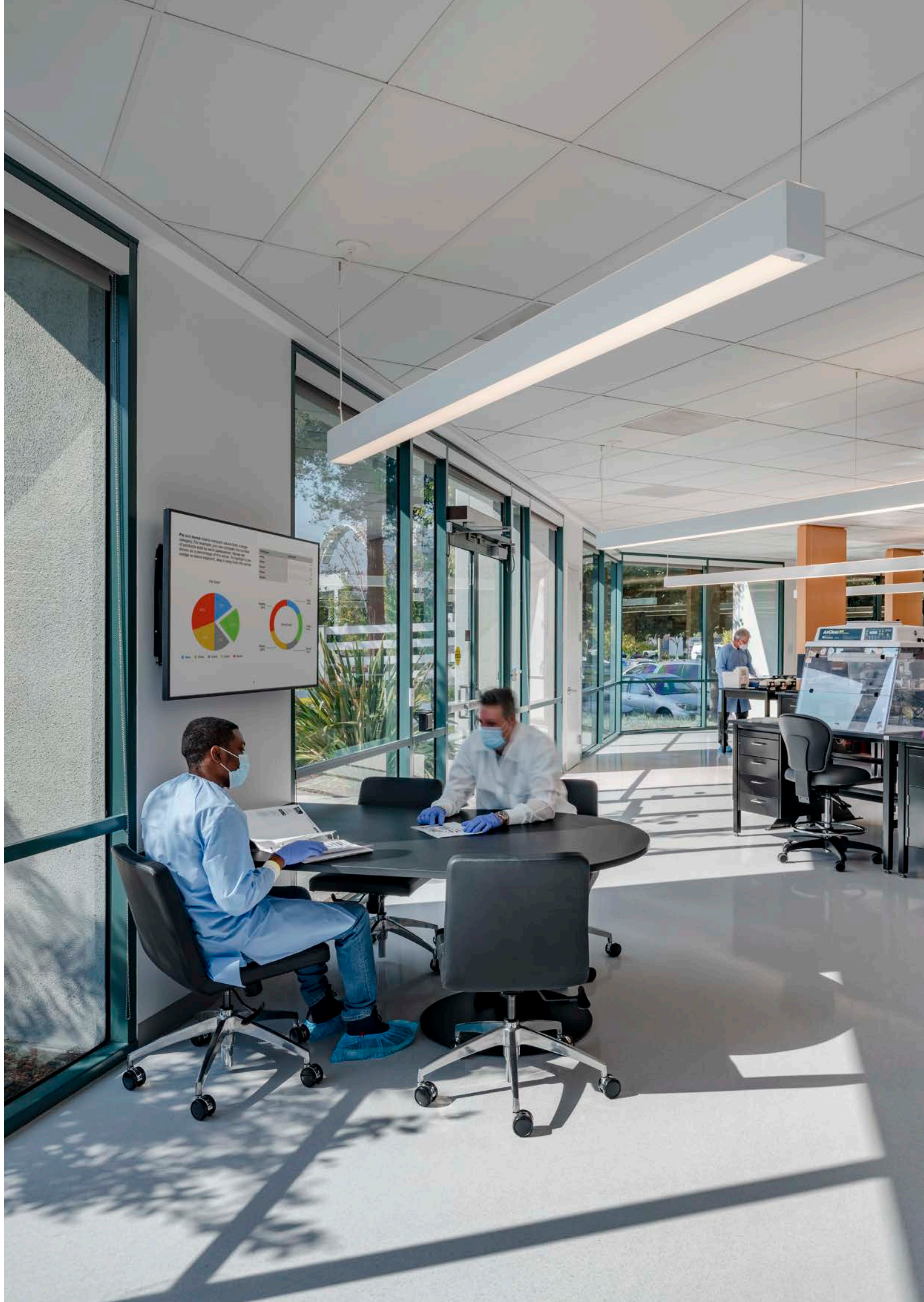
- Use natural materials to create a more pleasing environment and reduce stress for all
- Provide spaces with soft muted colours and avoid strong patterns in areas designed for concentration and contemplation
- Provide spaces with stronger colours, patterns and textures for hyposensitive types
- Leverage graphics and colour to aid in visual relief, wayfinding and creating memorable moments

Management Control Requirements:

- Allow assigned dedicated workplaces for neurodiverse staff that require routine
- Provide access to work points in low traffic areas
- Allow free choice of work points and movement between them to empower individual with choice, options and the ability to find a space that is suited to their needs and neurotype
- Clearly communicate intent and purpose of changes within the workplace
- Allow individuals to have a greater participation in the management of their workplace

Furniture Requirements:

- Provide adjustable ergonomic furniture, e.g. sit-to-stand desks and adjustable chairs
- Provide a variety of options, with different degrees of screening that allow individuals to find a space that supports their preferences
- Provide appropriate, accessible storage



Neuroinclusive Scientific Neighbourhood

The neuroinclusive considerations outlined on the previous page were used as a brief and applied to the typical commercial lab environment, to create a transformative neuroinclusive scientific neighbourhood as illustrated in the plan opposite and the following pages. Creating a rich and diverse interior landscape is at the heart of neuroinclusive design.

Overall, the most notable difference between the traditional plan and the new neuroinclusive scientific workplace layout is the significant increase in addressing the modalities or work and creating a variety of neurozones designed to address the needs of the many, instead of the few. This richness is not random. The neighbourhood has an ordered legibility and clarity to the modalities of work. The key organisational moves include:

- The 100-person neighbourhood subdivided into two wings of c40-50 researchers
- Central bay accommodates **'congregate'** and **'creative'** spaces in the lab to support collaboration between researchers and departments
- A central **communal** social zone has been added into the write-up space. This node could also be used for feature vertical circulation to other floors for larger tenancies
- Open **'commune'** modes of space are located either side of the central bay on both the lab and write-up zones. These spaces retain the efficient layout and density that are the hallmark of labs but have a wider range of furniture and benching to allow researchers to work more collaboratively in smaller research groups

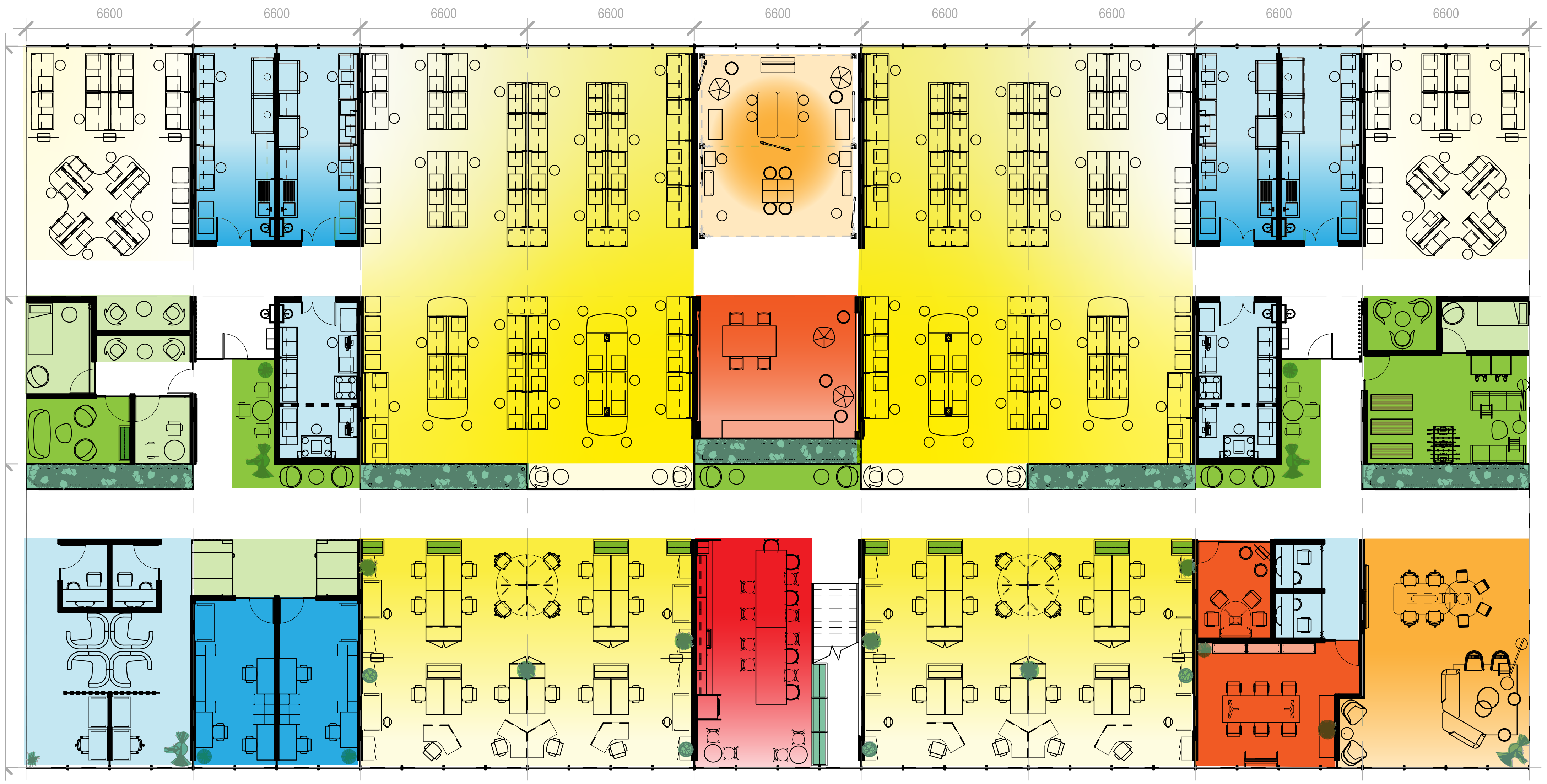


Figure 11: Neuroinclusive Lab Layout

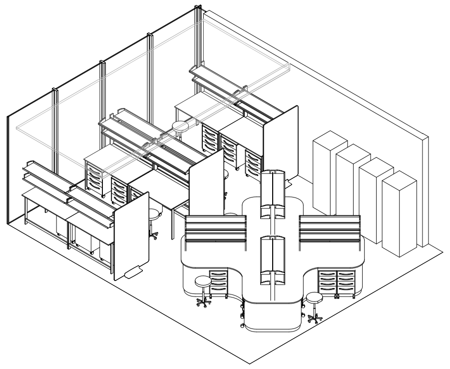
Hypo	Hyper		Hypo	Hyper	
		Social			Commune
		Congregate			Contemplate
		Create			Concentrate

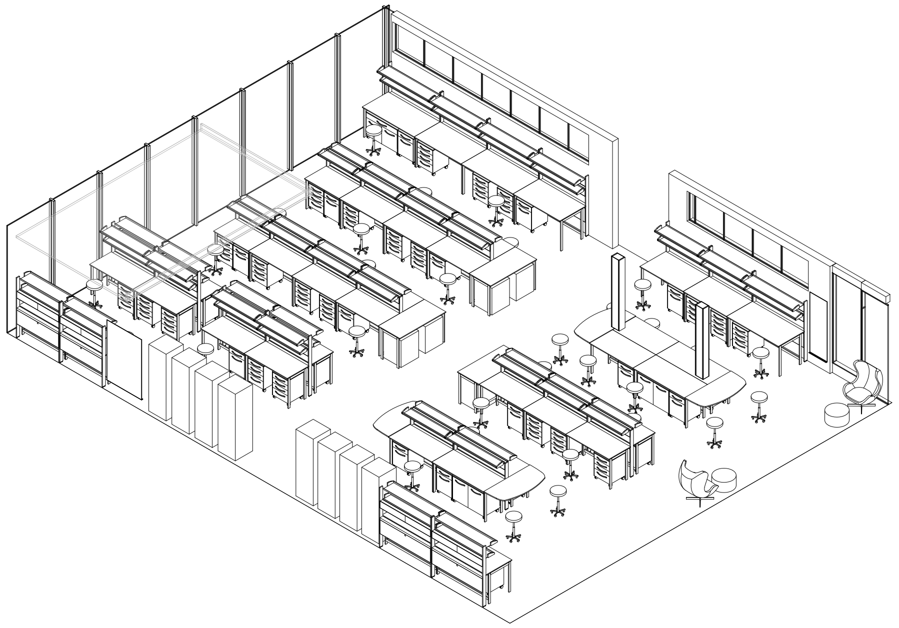
- The main circulation running left to right through the neighbourhood is modulated by a series of biophilic terrariums and alcoves which not only breaks up long linear views and creates quieter seating spaces for more hypersensitive researchers, but brings nature into the very heart of the floorplate as well.
- Creating a transparent barrier between the lab and write up spaces with fully glazed partitions with applied graphics and the terrarium to provide subtle veils for visual privacy
- **'Contemplative'** pods have been inserted at either end of the central zone as 'in-between' space accessible from both the lab and write up zones. These spaces are for informal break out and can be used for group working and meetings
- On the right the pod is more cellular to provide a range of quiet restorative spaces, whilst the left pod is configured for lively regenerative stimulus spaces for either a single person or small groups.
- More cellular workplaces and meeting pods have been integrated into the write-up zone to provide a wide range of acoustically separated workspaces for one to two people or small groups
- The corners of buildings have been democratised, rather than using them for cellular executive offices or sterile meeting rooms.
- The corner spaces are used as quieter **'commune'** workplaces with more acoustic absorption and organic furniture and bench configurations.
- Within the write-up area, in the left corner is a quieter concentration workspace, whilst the right corner is envisaged as a dynamic **'create'** space which can be set up as maker space, for group working or meetings.

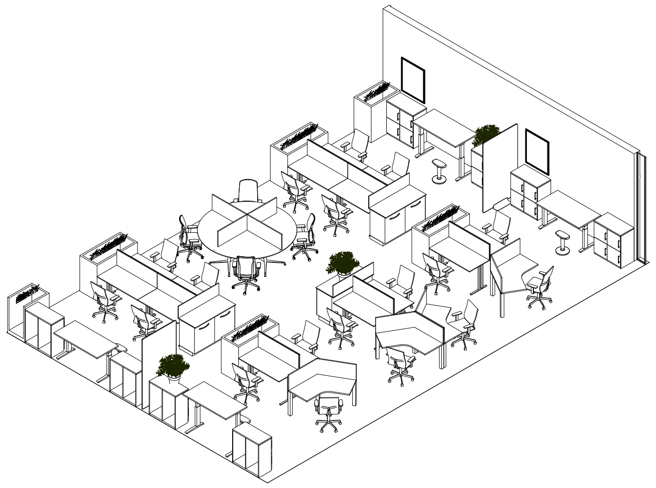
We believe the net result of all of the above design changes can transform the traditional lab environment into a neuroinclusive space that brings nature into the very heart of the floorplate.

Typical Scientific Workplace of Today:		Neuroinclusive Scientific Workplace of Tomorrow:
1. Lacks access to natural daylight	→	1. Access to natural daylight and views
2. Need for cleanliness often equals white, sterile, impersonal spaces	→	2. Elements of hospitality and stylization to humanise the space
3. Limited or no biophilic elements	→	3. Terrariums for controlled biophilia. Colour and natural materiality
4. Noisy equipment	→	4. Quiet and buzzy aural environments
5. Cluttered spaces	→	5. Ordered range of different spaces
6. Limited mobility of occupants as they are often tied to one spot	→	6. Ability to choice type of space
7. Lack of variety, choice, control	→	7. A menu of modalities of workplace
8. No space to retreat to	→	8. A range of restorative and regenerative spaces

Kit of Parts







1 Commune Lab – Hyper

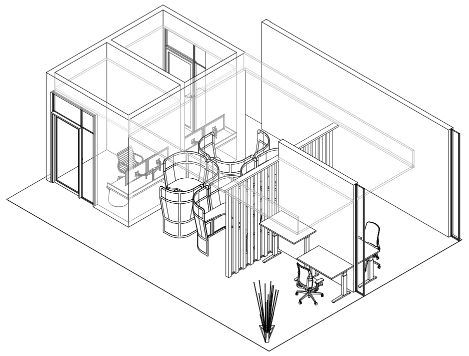
Acoustically quieter lab space with visual privacy screens next to windows with more informal bench layout adjacent to lab corridor.

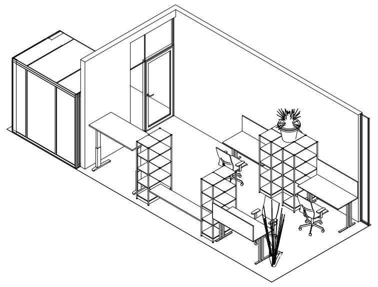
2 Commune Lab – Hyper to Hypo

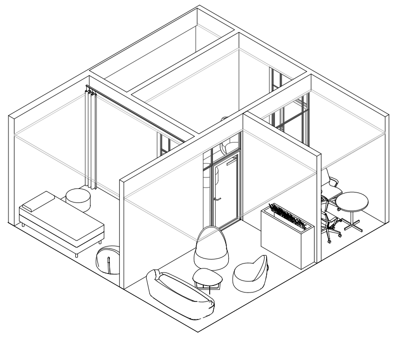
Open lab space with traditional linear lab benches, but with a staggered layout. Integral curved end benches allow break out spaces next to external window and internal terrariums.

3 Commune / Processing Workplace – Hyper to Hypo

Similar to 2, this is an open workplace arrangement but with a wide range of furniture types from sit to stand, circular, angled to provide visual and spatial variation.







4 Concentrate Workplace – Hyper

Acoustically quieter corner workplaces with different levels of visual and acoustic privacy.

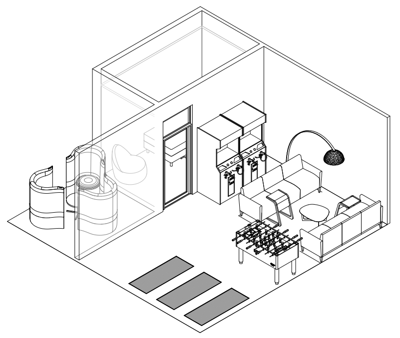
5 Concentrate Workplace (Shared Office) – Hypo
Contemplate Space (Pod) – Hyper

This zone has two types of workplaces adjacent to each other. The main space is a shared cellular office next to the window, with single person acoustic pods along the corridor.

6 Contemplate (Shared Pod) Hyper & Hypo

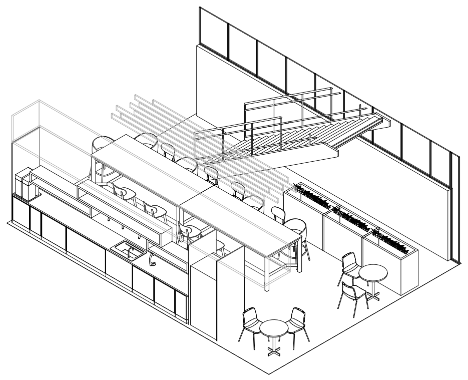
This pod has a range of different sized rooms from single person room that can used for first aid or as restorative chill out space, to small rooms and alcoves for varying degrees of private hypersensitive chill out and contemplation.

Kit of Parts



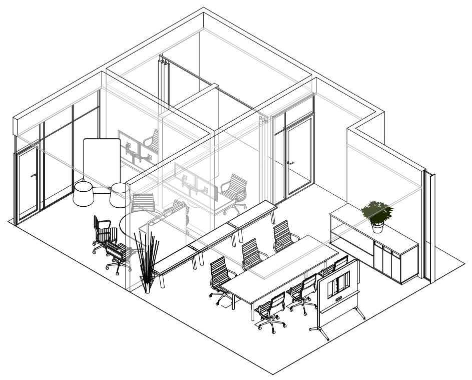
7 Contemplate (Shared Pod) Hypo & Hyper

This pod is similar to 6, but is configured for hyposensitive stimulation, with a range of cellular spaces to larger group space for yoga, games, and interactive group working.



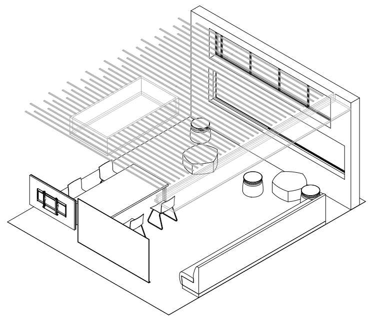
8 Convivial / Social Shared – Hypo

This space combines a kitchenette, range of café type seating together with feature stairs to become the vibrant heart of the neighbourhood and engender serendipitous collaboration moments.



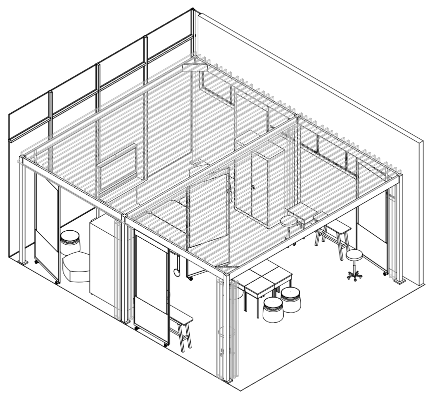
9 Congregate Workplace – Hypo
Concentrate workplace – Hyper

This pavilion has a range of both congregate/hypo and concentrate/hyper modalities from meeting rooms to alcoves and niches all contained within a unified architectural element which can be demountable for flexibility and insertion into existing buildings.



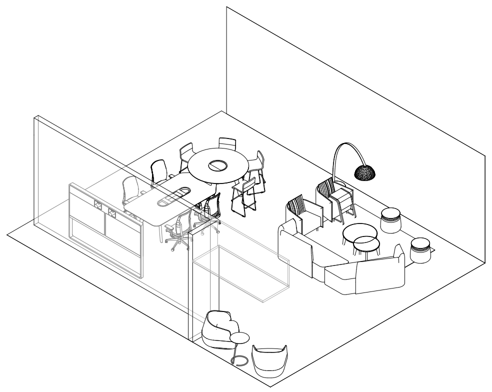
10 Congregate / Meeting Space Lab – Hyper to Hypo

This space is located in the heart of the open lab area and is designed with appropriate wall materials and suspended ceiling slatted materials that align with strict lab sterile and cleaning protocols. But it is still an informal group meeting and workshop area with a range of furniture for researchers to enjoy a break-out zone without the bother of exiting containment spaces.



11 Create Lab – Flexible maker space – Hyper to Hypo

Located directly opposite space 10, this space is a creative maker space with movable lab furniture and suspended support ceiling to hang equipment or servicing for different science experiments.



12 Create Space – Hyper & Hypo

This space is located on a corner and includes a wide range of furniture configurations from a sofa seating area to range of table layouts with AV screens and alcoves for hypersensitive chill out moments.

Tomorrow's Neuroinclusive Scientific Neighbourhood

While the kit of parts illustrates of the wide range of spaces and environments that have been created for our transformative neighbourhood, figure 12 brings all these ideas together into a single isometric image which highlights the rich, vibrant, and diverse scientific workplace that we have collectively imagined.

HOK has already implemented many of these core principles into existing projects as we continually strive to design for inclusion and the success of all. The precedent images below give you a very tangible glimpse of these spaces in reality.

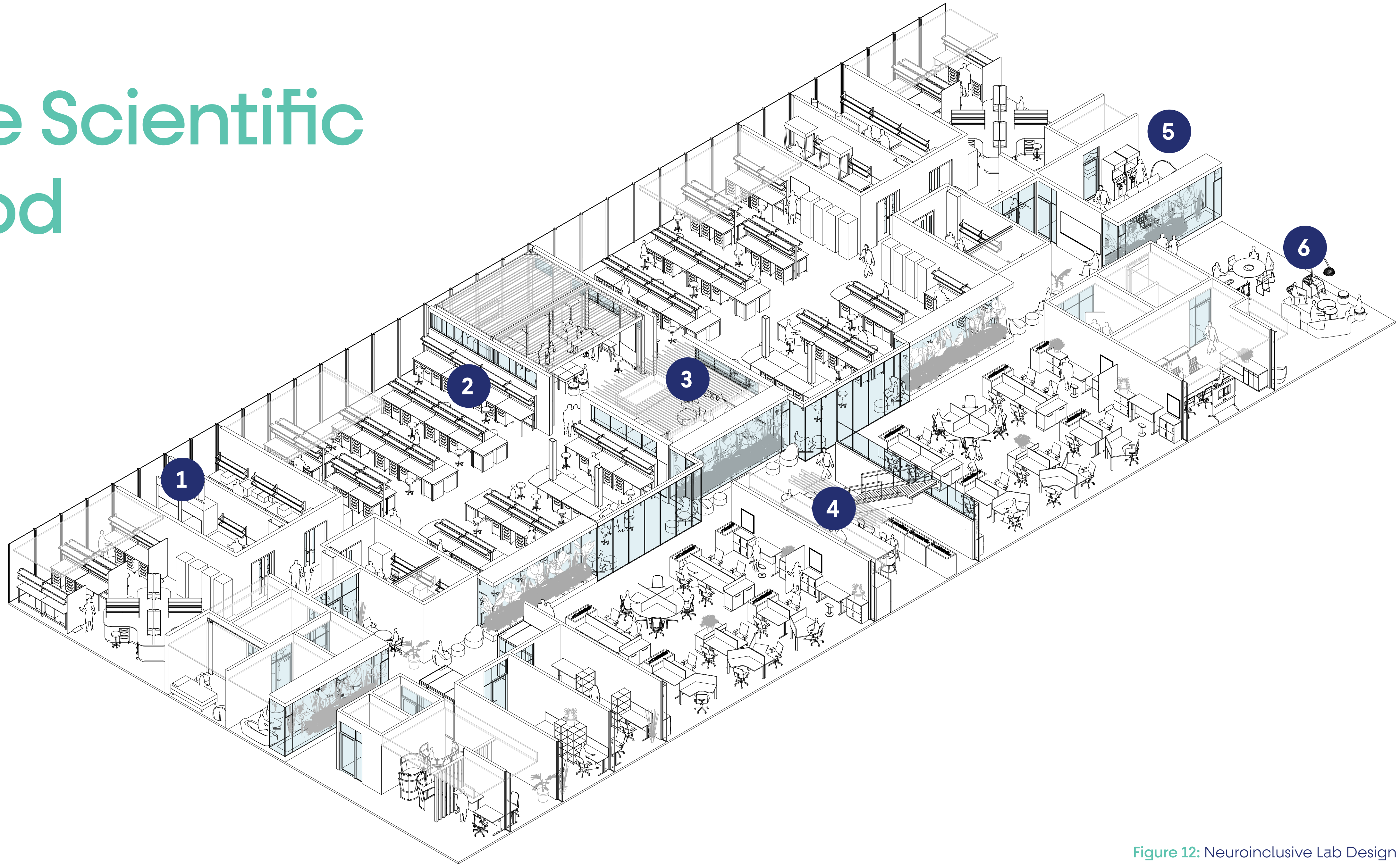
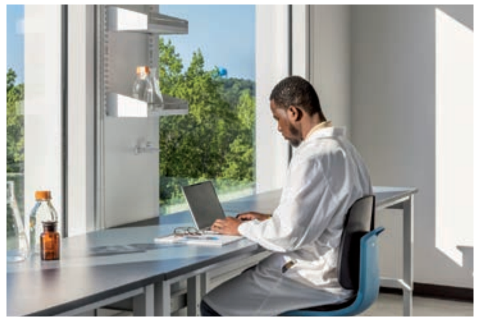


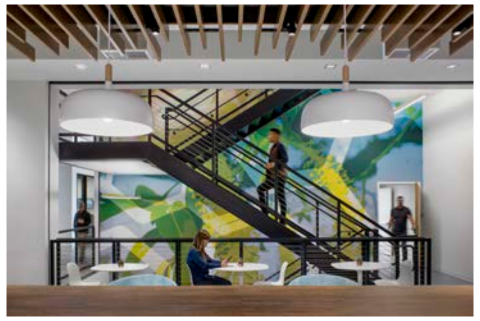
Figure 12: Neuroinclusive Lab Design



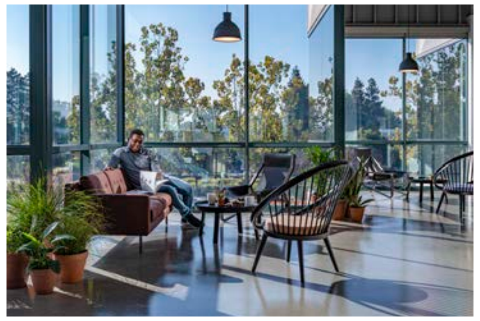
1 Concentration Space within Lab

2 Commune / Processing Workplace

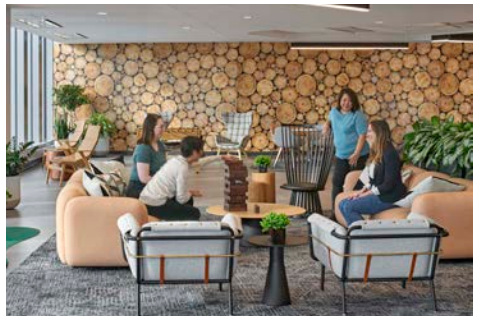
3 Congregate Space within Lab



4 Convivial Social Shared Space



5 Contemplation Space



6 Create Workplace

Vision of a Neuroinclusive Tomorrow

The view below is of the open communal lab space with the congregate space in the centre of the lab. From the lab, we look through the glazed screen and terrariums into the open write up spaces with the vibrant social space in the centre.

This vignette distils our ideas and vision of a neuroinclusive scientific neighbourhood that is realistic, embraces the profound understanding of what is required to provide a workplace that supports and delights everyone in equal measure.

In conclusion, when environments aren't designed to be supportive of sensory processing, individuals are forced to find ways to cope. For neurominorities, this is too common an occurrence and can be physically and mentally taxing.

By incorporating best practices for inclusive design, we can create environments where all can thrive.

There is a compelling human and business benefit to designing for inclusivity, and it is the right thing to do.

Summary

The data from both the survey and design workshop identified a number of important findings that should be considered when designing and creating neuroinclusive laboratory work environments.

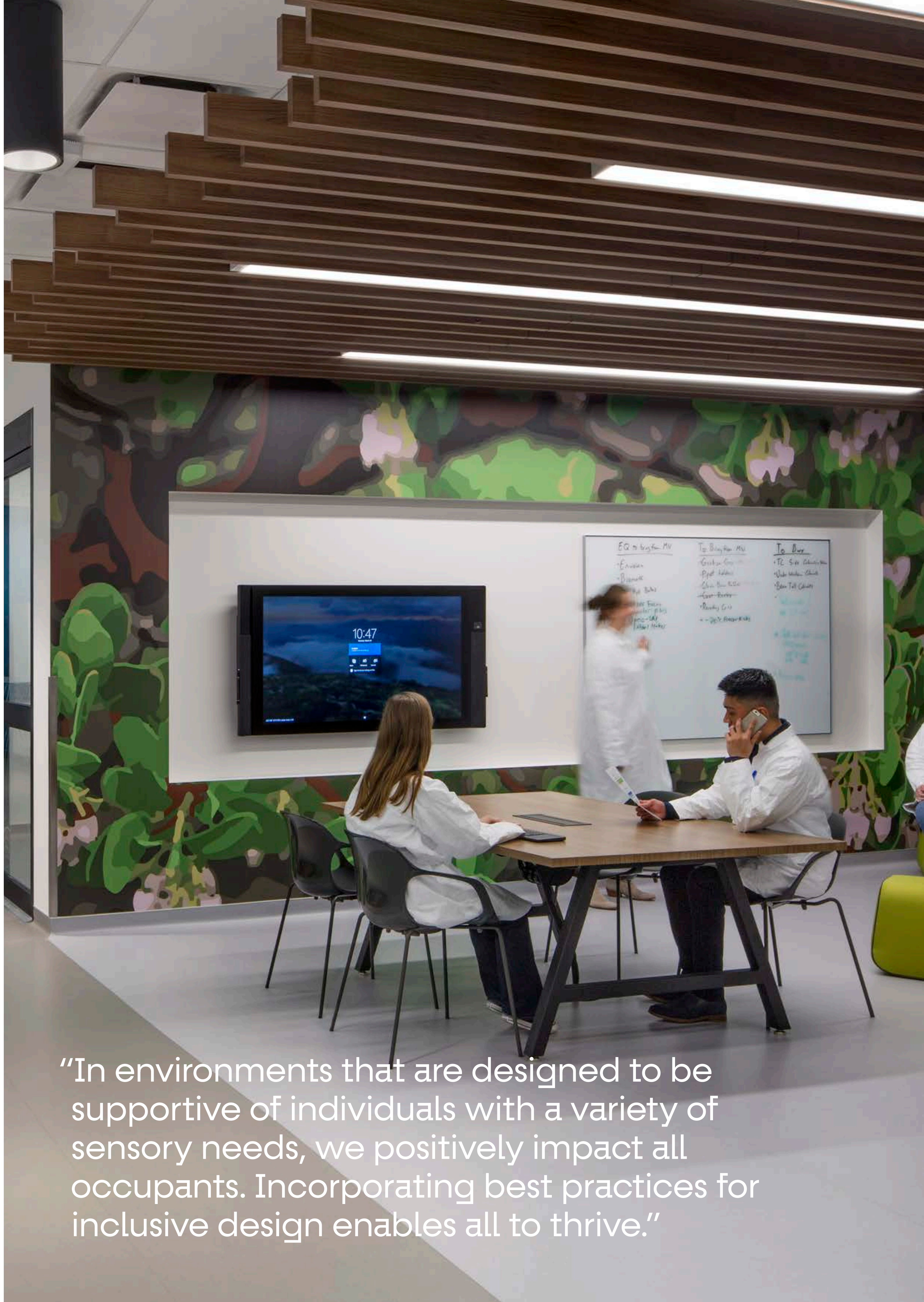
Regardless of neurotype, certain environmental stimuli associated with sounds and temperature can be challenging to most employees. Likewise, some design strategies are considered effective by most employees regardless of neurotype, e.g. having a designated space within the lab, whilst also having a choice of spaces to access that suit different needs, natural daylight and ergonomic furniture. However, it is also clear that employees who identify as neurodivergent are more sensitive to auditory, visual and tactile environmental stimuli and find associated design elements such as patterns, sounds and textures more challenging than neurotypical employees. Neurodivergent employees also find psychosocial elements such as proximity of others and numbers of other people present, more challenging.

Design strategies that are identified as being particularly effective for neurodivergent employees include 'spaces that allow you to move, pace, fidget' and 'work points located in low-traffic areas.' These are again associated with psychosocial aspects of the work environment. It is also interesting to note that employees who indicated that they were 'not sure' about their neurotype, were more similar to neurodivergent employees in terms of their sensitivity to auditory environmental stimuli. It is therefore recommended that employers should consider providing more opportunities for neurodiversity awareness training to understand the specific needs of employees and to enhance opportunities for assessment/diagnosis.

Whilst the above findings reveal important differences between neurotypical and neurodivergent employees, it is also essential to understand the different needs and sensitivities of employees that identify as neurodivergent. The majority of neurodivergent employees indicated that they had two or more conditions (co-morbidity), and these employees are more likely to be sensitive to visual stimuli, find texture elements more challenging, and to find spaces that allow one to move, pace, and fidget as an effective design strategy. In contrast employees that identify as ASD are less likely to find spaces that allow one to move, pace, and fidget, and access to stress balls, fidget furniture, or game rooms as an effective design strategy. For employees that identify as ADHD, having access to stress balls, fidget furniture, or game rooms is an effective design strategy, and they are generally less sensitive to proprioceptive and vestibular environmental stimuli. Finally, employees with dyslexia are generally less sensitive to environmental stimuli compared with other neurodivergent groups and are more likely to find operational strategies such as assistive software and technology more effective.

The findings from the workshop complement those from the survey and highlight key environmental characteristics that should be considered when designing neuroinclusive laboratory environments. In particular, there is a need to provide employees with a choice of spaces to move to for work, relaxation, socialising and restoration; careful consideration of appropriate stimulation levels (both physical and psychosocial) to enhance comfort; inclusion of natural elements/views; provision of ergonomic furniture; and the reduction of spaces that provide too much visual access to employees. Finally, the workshop also highlighted the need for employers to provide opportunities for their employees to contribute to the 'management' of workspaces so that these can better reflect the different needs and sensitivities of both neurotypical and neurodivergent employees.

In environments that are designed to be supportive of individuals with a variety of sensory needs, we positively impact all occupants. Incorporating best practices for inclusive design enables all to thrive.



"In environments that are designed to be supportive of individuals with a variety of sensory needs, we positively impact all occupants. Incorporating best practices for inclusive design enables all to thrive."

HOK Neurodiversity Disclaimer

Neurodiversity is a term used to describe a broad range of conditions, some of which likely will be unresponsive to design solutions. HOK's approach to inclusive design is based on our experience as designers and architects with the objective of providing a wide range of options for users with different needs. Any attempt to address the needs of neurodiverse individuals should also include review of human resources policies, implementation of technology solutions and building operations among other considerations. HOK does not represent that any design solution discussed in this article is capable of achieving any specific outcome for an individual user.

Get in Touch

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This workplace neurodiversity research project is a collaboration between HOK International Ltd, Advanced Research Clusters Portfolio Management Limited and Dr. Edward Edgerton of the University of the West of Scotland. The aim is to create design recommendations for the inclusive scientific workplace and lab.

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ARC Advanced Research Clusters