Transcendental Approaches to QM: Lessons from Bohr

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Structure of my talk

1. What do we mean with “transcendental”?
2. The Transcendental Reading of Bohr
3. Problems with a Transcendentalised Bohr
4. Proof for the Popularity of Bohr

What do we mean with "Transcendental"?

"I call transcendental all knowledge which is occupied not so much with objects as with the mode of our knowledge of objects, in so far as this mode is to be possible *a priori*." (Kant 1965, A11/B25)

"The word 'transcendental' […] does not signify something passing beyond all experience but something that indeed precedes it a priori, but that is intended simply to make knowledge of experience possible" (Kant 1985, 373)

"[T]he transcendental method is the procedure according to which, beginning from the reality of an object, one can infer the conditions of the possibility." (Hartmann 1912, 125)

What do we mean with "Transcendental"?

Starting from de facto experience or a given body of knowledge, transcendental analysis "works backwards" to identify the **necessary conditions of the possibility** of this experience.

For instance, in everyday situations we are competent observers in the sense that we are usually able to distinguish objectively existing physical things from, say, figments of our imagination. Doing so requires an implicit concept of objectivity. Transcendental analysis is in the business of spelling out (the structures behind) this concept.

However, such a project is by no means limited to the manifest image…

What do we mean with "Transcendental"?

> "[E]laborating a transcendental epistemology of physics [means to undertake] a reflective research about the indispensible [sic!] preconditions of our knowledge and their relevance to the structure of physical theories."
>
> (Bitbol, Kerszberg & Petitot 2009, 2)

This is the same idea of unearthing the necessary conditions of the possibility of experience and knowledge, just now with a focus on a special realm.

Or in a similar vein…

What do we mean with "Transcendental"?

"Until now almost all philosophical investigations of quantum theories have either taken the concept of objectivity for granted or prescribed it as some external criterion, according to which the theories are judged. [...] I adopt the opposite approach. I start with the premise that quantum theory conveys knowledge of the microscopic world and regard the general meaning of objects as a question whose answer lies within the theory. This work asks quantum theory to demonstrate its own objectivity by extracting and articulating the general concept of objects it embodies. [...] What general conditions hold for us and the world we are in so that objects, classical and quantum, which are knowable through observations and experiments, constitute reality? How is knowledge of the quantum world possible? These are part of what Kant asked: How is empirical knowledge in general possible?"

(Auyang 1995, 7)

What do we mean with "Transcendental"?

So, let's summarise. Transcendental analysis is a

- **regressive** undertaking in which we start from a given experience or body of knowledge in order to then
- unveil the **necessary conditions of the possibility** of this kind of experience or body of knowledge.

In light of this characterisation, three additional remarks are in order…

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First, there is an important epistemological implication in all this: Experience, on this view, is not just the passive registering of data. In order for experience to happen at all, transcendental structures must already be in place.

For instance, to competently distinguish between a physical object and a figment of imagination, a concept of objectivity must already be operative.

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- unveil the **necessary conditions of the possibility** of this kind of experience or body of knowledge.

Second, there is a specific relationship between the level of concrete experience and the NCPs preceding it: If x is a NCP and thus constitutive for the body of knowledge y, then, on pain of circularity, we cannot rely on y to account for x.

This is typically seen to be a *logical* point. We'll come back to it…

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- unveil the **necessary conditions of the possibility** of this kind of experience or body of knowledge.

Thirdly, we must be cautious with regard to the notion of **necessity** that is at work here. Contemporary transcendentalists typically work with a notion of **conditional necessity:** "certain constitutive principles are necessary *under the condition that a certain practice of research is implemented*" (Bitbol, Kerszberg & Petitot 2009, 17). When practices of research change (as they do in science history), the constitutive principles may change too.

Transcendental Reading of Bohr

A crucial idealization in CP concerns the possibility of *ideal measurements*, i.e. measurements that do not alter the state of the measured system.

Although actual measurements do not live up to this ideal, CP treats this as a contingent matter of technological realizability.

Bohr considered Planck's discovery of the universal quantum of action $\hbar$ as the essence of QM because it undermines the notion of an ideal measurement.

Transcendental Reading of Bohr

$\hbar$ connects properties of particles (energy E and momentum p) to properties of waves (frequency f and wavelength) through the two equations

$$E = \hbar \cdot f,$$

and

$$\lambda = \frac{\hbar}{p}.$$

Two things follow from this: First, the value of physical properties like radiation or energy cannot come in infinitely small amounts but is always quantized. Second, and *contra non-disturbance*, measurement interactions can never be neglected in QM: Since the $\hbar$ is finite in size, any measurement interaction is at best of the same order of magnitude as the interactions it is supposed to measure.

Transcendental Reading of Bohr

"What we observe is not nature in itself, but nature exposed to our method of questioning" (Heisenberg 1958, 58).

Or, in Bohr's words, we must accept the fact of a fundamental "inseparability of knowledge and our possibilities of inquiry" (Bohr 1960, 12).

This must be taken very seriously: For instance, it makes no sense to say that we are "*disturbing* [or *creating*] a phenomenon by observation" in QM (Bohr 1996, 24).

The reason is that words like "disturb" or "create" imply an ontological judgment about the system pre-observation: there is or isn't something that can then be disturbed or created by an act of observation. But "inseparability of knowledge and our possibilities of inquiry" means that pre-observation talk is *meaningless*.

Transcendental Reading of Bohr

What many found puzzling is Bohr's insistence that the "description of the experimental arrangement and the recording of observations must be given in *plain language*" (Bohr 1958, 3).

So, no matter how far quantum mechanics departs from classical physics, the description of the experimental setups must always be given *classically*.

"[T]he mathematical formalism of quantum mechanics [...] merely offers rules of calculation for the deduction of expectations about observations obtained under well-defined experimental conditions specified by *classical physical concepts*." (Bohr 1963, 60)

Transcendental Reading of Bohr

This is true even if we make our experimental setups part of a quantum description. Even then,

> "some ultimate measuring instruments, like the scales and clocks which determine the frame of space-time coordination [...] must always be described entirely on classical lines, *and consequently kept outside the system subject to quantum mechanical treatment*." (Bohr 1996, 24)

Transcendental Reading of Bohr

This sharp rift between quantum and classical puzzled many because it seems to leave us with two overall options (cf. Zinkernagel 2015):

Either we accept a **two-world ontology**; but Bohr is very clear that the line between quantum and classical is drawn arbitrarily, on the basis of *pragmatic* considerations.

Or we read Bohr along classical **instrumentalist** lines, suggesting epistemic agnosticism regarding the quantum realm. But there is much in Bohr that goes beyond quantum-agnosticism. At the very least, according to him, QM embodies an epistemology that concerns “what we can *say* about [quantum] nature” (Bohr, quoted in Petersen (1963), 12).

Transcendental Reading of Bohr

It is in light of these two options that transcendentalists advocate a third possibility:

> “[J]ust as Kant did, Bohr undertook a reflective analysis of the generic structure of our capability to know. However, unlike Kant, Bohr distanced himself from a study of mental faculties such as sensibility and understanding. He rather focused on a technological counterpart of sensibility, namely, the measuring apparatus, and on the intersubjective counterpart of understanding, which is common language.” (Bitbol 2017, 52; cf., also, Bitbol & Osnaghi 2013)

Transcendental Reading of Bohr

The basic idea here is that Bohr considered the experimental setup (and common language) as the **necessary condition of the possibility of quantum experience** in the transcendental sense of the term.

For our interpretation of Bohr, this has three main consequences…

Transcendental Reading of Bohr

First, if experimental setups are NCPs for quantum experience, then it naturally follows that there is no meaningful pre-observation discourse. To engage in such discourse is what Kant called the "*transcendental illusion*": It is speculative metaphysics that oversteps the boundaries of possible experience and its relationship to the conditions of its existence.

This also fits very well with Bohr's definition of *phenomenon*: "I strongly advocate limitation of the use of the word *phenomenon* to refer exclusively to observations obtained under specified circumstances, including an account of the whole experiment" (Bohr 1948, 317)

Transcendental Reading of Bohr

Second, if experimental setups are NCPs, then the fact that they must be described classically does not have any *ontological* implications.

> "There is nothing in the *physical* nature of macroscopic objects that distinguishes them from the microscopic ones, and which rules out the possibility of describing them as quantum systems. Bohr's concern is rather to emphasise the specific *function* that the measuring apparatuses accomplish in the system of knowledge: that of [...] fulfilling a condition of the possibility of objective experience." (Bitbol & Osnaghi 2013, 152-3)

(Remember Kant's definition of transcendental as being "occupied not so much with *objects* as with the *mode of our knowledge of objects*"...)

Transcendental Reading of Bohr

This also explains why introducing an experimental setup is *necessary* while it is at the same time *arbitrary* where one draws the quantum/classical line.

Although the scope of QM is unrestricted, we need to introduce a experimental setup *somewhere* because introducing the setup is the NCP to have quantum experience at all.

This, btw, is reminiscent of Peres' and Zurek's views on the matter:

> "[A]lthough quantum theory is universal, it is not *closed*. Anything can be described in it, but something must remain unanalysed. [A]lthough it can describe *anything*, a quantum description cannot include *everything*."
>
> (Peres & Zurek 1982, 810)

Transcendental Reading of Bohr

Third, and closely related to the last point, remember Bohr's remark that

> "some ultimate measuring instruments [...] must always be described entirely on classical lines, *and consequently kept outside the system subject to quantum mechanical treatment*." (Bohr 1996, 24)

That the measuring instruments must remain outside the quantum description is a purely *logical* point: If x is NCP for y, x cannot be accounted for within y.

This is a version of the traditional Kantian argument against naturalised epistemology: If epistemology deals with the question "how is empirical knowledge possible", then it is self-defeating to rely on empirical knowledge to answer this question.

Problems with Immanuel Bohr

There are many passages in Bohr which seem to fit perfectly well into this interpretational framework. Bohr repeatedly uses a Kantian language when he refers to “the measuring instruments [as the] *conditions* under which the phenomena appear” (Bohr 1949, 246).

What is more, on a more systematic level, Bohr’s brand of transcendentalism might seem to be the best of two worlds: It gives an epistemologically more nuanced picture of how quantum experience is more than just a passive registering of data.

But unlike Kant, there is no reference to mental faculties or the subject more generally. This might appear desirable for those who think that a well-behaved theory is one which is purged from all operational, subjective or experiential notions.

Problems with Immanuel Bohr

But there are problems as well…

Why is it, exactly, that the (final) experimental setup is considered the NCP for having any experiential contact with the quantum realm? The reasoning seems to be that the (final) experimental setup enjoys this status because there wouldn't be any quantum experience if this (final) experimental setup wasn't implemented.

And remember that this is also the reason why the (final) experimental setup falls outside the scope of a quantum description.

My worry is that, following this criterion, there are *many more things* that deserve to be called a NCP for quantum experience.

Let me illustrate by means of a simple example…

Problems with Immanuel Bohr

The (final) experimental setup enjoys the status of a NCP for quantum experience because there wouldn't be any such experience if the experimental setup hadn't been put in place first.

However, on the assumption that the outcome of the (final) measurement apparatus must be registered by a human observer, there also wouldn't be any quantum experience if, say, *the lab wasn't filled with the sufficient amount of air*.

But would it make any sense to call the air in the lab a *NCP?*

Would it make any sense to *deny that the oxygen in the lab can be described within QM?*

Problems with Immanuel Bohr

The obvious answers are “no”, and I take it that Bohr would agree.

But I don’t see any room in Bohr’s account to distinguish between the experimental setup on the one hand and purely contingent (and hence epistemically irrelevant) background conditions like air in the lab on the other.

Note also that this argument doesn’t depend on *human* observers for whom oxygen is essential for contingent biological reasons. Just replace “air in the lab” with “being located on a terrestrial instead of a gas planet” and you have the same outcome…

Problems with Immanuel Bohr

One strategy to deal with this problem would be to argue as follows:

In a way, it is indeed correct to say that *every* event is somehow causally linked to everything else in the event's past light cone.

However, whether a particular condition just happens to be in an event's past light cone or is necessary for the possibility of the event's occurrence is, like everything else, a *scientific* matter which can only be decided by the looking at the relevant theory, in our case QM.

But this argumentative strategy isn't available to Bohr (if, of course, it is correct to read him transcendentally…)

Problems with Immanuel Bohr

Remember what I said about the relationship between experience and the NCPs that precede it…

If x is a transcendentally necessary condition for y, then, on pain of self-defeat, we cannot rely on y to account for x.

However, if we were to depend on quantum mechanics to identify the conditions that are transcendentally necessary for the possibility of quantum experience, then we would be self-defeating in exactly this way: we would commit the fallacy of analyzing the transcendentally necessary conditions within the very framework for which they are constitutive.

Problems with Immanuel Bohr

There is another obvious solution to this problem…

Remember the earlier definition of a conditional necessity as a necessity that depends on the implementation of *"a certain practice of research"* (Bitbol, Kerszberg & Petitot 2009, 17).

Following this definition, one could argue as follows: Whether x is a NCP in the transcendental sense of the term depends on whether x *is part of a distinctive practice that must be carried out in order to achieve a certain epistemic end*.

While arranging measurement apparatuses in a specific manner is a practice that serves a certain epistemic end, having air in the lab or being on a terrestrial planet are not connected to epistemic practices in any obvious way.

Problems with Immanuel Bohr

But I don't think this strategy is available for Bohr.

The reason is this: By connecting the notion of NCPs with specific research practices and thus with specific epistemic goals, one is smuggling an epistemic *agent* and hence a conscious *subject* into the description of QM.

While I am not denying that this might be a perfectly reasonable thing to do, I don't think that this part of Bohr's official agenda. I agree that even when Bohr talks about experience or observers, "his references [...] refer to the observer *qua physical system, not qua consciousness*" (Faye & Folse 2017, 5), and that "Bohr was always careful to physicalize the 'observer'" (Howard 2004, 671).

Here are two further quotes further corroborating the view that there is no subject in Bohr's account...

Problems with Immanuel Bohr

> "Since, in philosophical literature, reference is sometimes made to different levels of objectivity or subjectivity or even of reality, it may be stressed that the notion of an ultimate subject [...] find[s] no place in an objective description as we have defined it." (Bohr 1954, 79)
>
> “The description of atomic phenomena has in these respects a perfectly objective character, in the sense that no explicit reference is made to any individual observer.” (Bohr 1937, 310)

Hence my challenge for a transcendental reading of Bohr stands: There is no way to distinguish between NCP in an epistemically interesting sense of the term and purely contingent background conditions like air in the lab or being located on a terrestrial planet. But now for the grand finale...


I HATE THEM SO MUCH!

Thanks for your attention!

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Conclusion

As we know, any mention of subjectivity or consciousness in relation to foundational questions of QM received a lot bad press.

The main reason is the “consciousness causes collapse”-view: According to this view (or, rather, a cartoonish representation of it), consciousness is, first, completely separated from physical reality, and, secondly, causes the wave function to collapse, thus “solving” the measurement problem.

This view was heavily criticized by Hilary Putnam and Abner Shimony, thus making any subsequent reference to consciousness or subjectivity seem suspect right from the outset.

Conclusion

As I have mentioned, the transcendental Bohr might be viewed as an alternative: One gets a more sophisticated epistemology of how quantum experience is constituted without any reference to consciousness or subjectivity.

However, if my arguments hold, things aren't that easy…

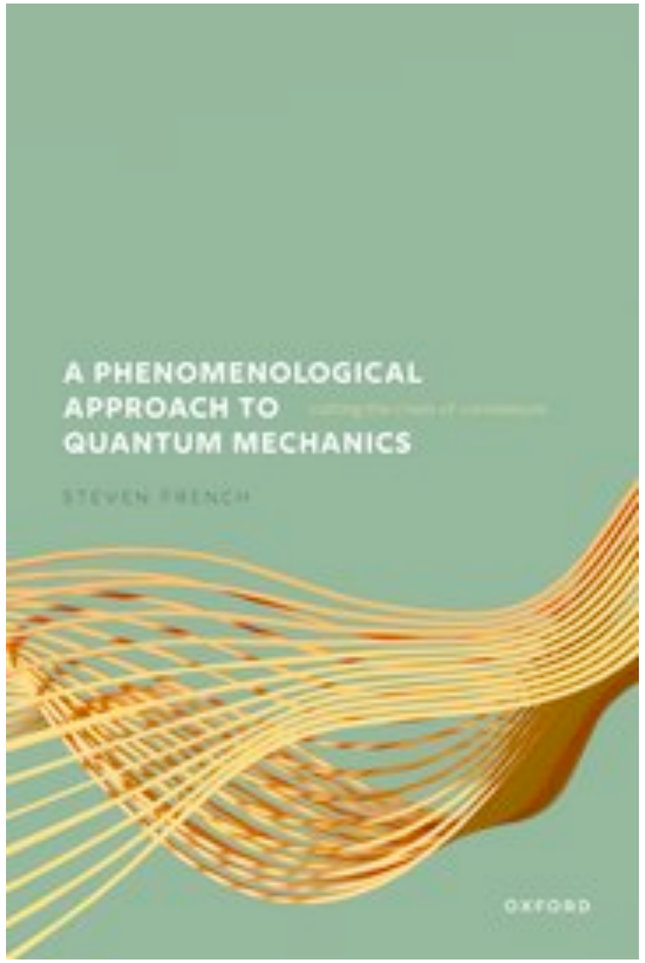
If we start from the "inseparability of knowledge and our possibilities of inquiry" (Bohr 1960, 12), then the resulting interpretation of QM must also include reference to an observing subject that sets up measuring apparatuses to achieve particular epistemic goals.

Without this reference it seems impossible to distinguish contingent background conditions from NCP in an epistemically interesting sense of the term.

Conclusion

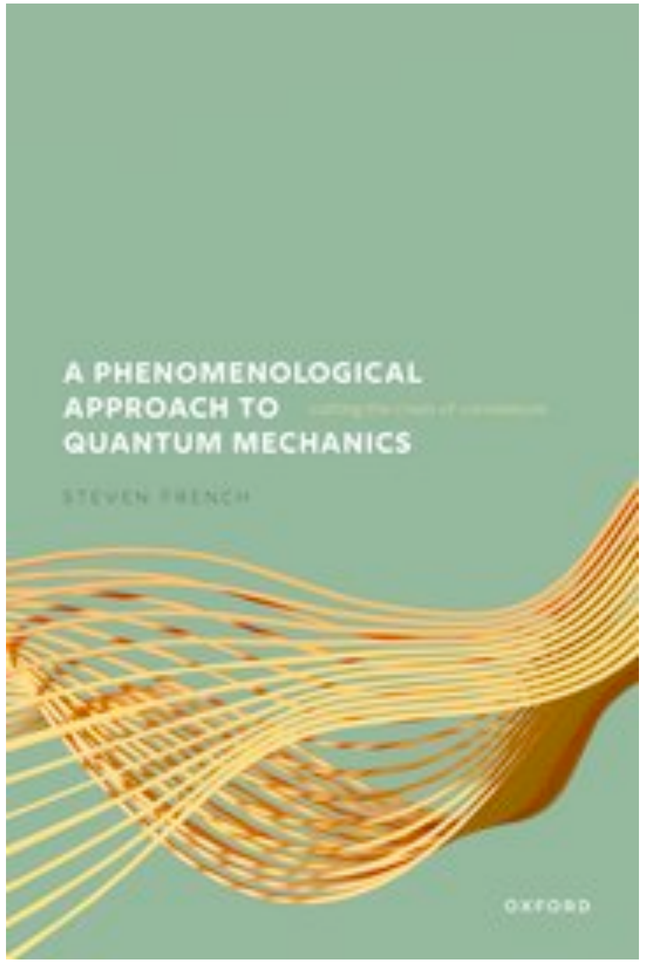
A way forward could be the recognition that there are ways to incorporate subjectivity without buying into the dualism that lies at the heart of the “consciousness-causes-collapse”-view.

One option in this regard is Fritz London’s phenomenological take on QM: Instead of viewing consciousness as being “outside” of the quantum description, the latter captures the fact that conscious observer and observed system are inextricably linked.



Conclusion

On this view, there is no collapse of the wave function. What we are referring to in this way is just a switch from the flowing stream of lived experience to an objectivation of a particular outcome through an act of reflection (or “instrospection”, as London calls it).



Conclusion

Similar ideas can be found in the literature about QBism, especially in the more phenomenological readings of Bitbol and De La Tremblaye.