Perception is shaped by context and associations. When we encounter a stimulus in the environment, there is a staggering amount of peripheral information that is also taken into account to perceive that stimulus. In speech perception specifically, listeners use acoustic cues to make assumptions about a talker’s traits, like their cultural background, age, and gender. These assumptions may change the way that the listener interacts with the talker (MacFarlane, 2014). Over the past 40 years, psychology research has explored purposefully introducing associations that prime beliefs and manipulate subsequent intentions and behaviours (Srull & Wyer, 1979). In 2013, Abbate et al. performed an experiment in which participants were primed for prosocial intentions –the desire to engage in behavior that benefited others, including helping, cooperating, comforting, and sharing– and then placed in a scenario where they could act on that desire. The experiment was successful in that prosocial priming significantly increased participant engagement in prosocial behavior in multiple contexts.

Recently, there has been a shift in the field to address the reduction problem: How does the brain process potentially innumerous cues in the environment to produce nonconscious behavior in real time (Bargh, 2016)? This question steps away from the traditional interest in the effects a cue has on behaviour, instead asking *how* multiple cues interact to produce the resultant behaviour. For instance, priming tends to be most effective when the targeted behaviour aligns with the participant’s goals and/or values (Bargh, 2016). In the context of speech perception adaptation, this question can be presented as how listeners use a range of cues within an interaction to understand a talker.

Speech can communicate various cues about the talker’s identity at the pragmatic, syntactic, wrote, and even phonetic levels. This encourages social grouping and prosocial behaviour. Social groups have a tendency to adopt similar language and usage patterns, and even imitate the speech cues of those perceived as belonging to their social group (Babel, 2012). Prior research suggests that individuals retain more detailed memories during word learning when those words are taught to them by someone perceived as belonging to their social group (Iacozza et al., 2020). Additionally, Trude and Brown-Schmidt (2012) found that listener’s use knowledge of talker identity as a talker-specific guide during online speech perception. Though unfavored speech alone has not been found to inhibit speech perception adaptation in listeners (Babel et al., 2019), it is another question entirely if prosocial intentions would facilitate this adaptation. Furthermore, previous studies (to the best of my knowledge) have failed to isolate potential prosocial cues from ingroup-biased expectations.

Listeners can understand novel talkers by comparing their expectations about how the talker will speak –formulated from their prior experiences with cues produced by other talkers they’ve encountered– with the experienced productions from that talker (Kleinschmidt & Jaeger, 2015). Thus, expectations about acoustic cues are likely biased towards ingroup members. Listeners then develop expectations for that specific talker and update their general expectations for future novel talkers. As a listener acquires more experiences with a specific talker, the malleability of their expectations for that talker tend to decrease (Kraljic et al., 2008; Saltzman & Myers, 2021; Tzeng et al., 2021). This is due to each experience with a specific talker having less weight as the number of those experiences increases. In a similar fashion, when individuals with larger social networks encounter a novel talker, their general expectations are less malleable (Lev-Ari, 2017).

Though listeners with larger social networks possess less malleable general expectations, they still communicate with more people and experience a wider variation in speech productions. This could suggest that listeners with larger social networks process their talker-specific expectations differently in order to maintain their relationships. Similar to how primed prosocial intentions facilitate relationship development by inspiring prosocial behaviour, could prosocial primes moderate a listener’s receptiveness to novel talkers? Could this be a possible response to the reduction problem in speech perception adaptation?

Prosocial Priming

The concept of priming has been an interest in psychology for several decades now, and it is accompanied by a body of work that reflects this timespan. The rationale behind priming is rooted in how the brain forms local associations: when Prime A is presented near Target Stimulus B, either spatially or temporally, subjects project the associations they have related to Prime A on to how they interact with Target Stimulus B. While this may sound unsurprising, the extent to which one stimulus can contaminate another is substantial: studies such as Abbate 2013 have found that an interaction with a stimulus can be primed without there being a connecting relationship between the two; individuals primed for procosiality via finding prosocial words in a word scramble activity were more likely to donate money and help someone who had fallen afterwards, despite believing the experiment had ended with the word scramble activity.

Priming a behaviour requires a combination of attitude and circumstance; the participant has an inclination to behave in a manner that reflects the prime, and then is introduced to a situation where they may act on that inclination. Primes can be processed both consciously and unconsciously. The effectiveness of a prime is facilitated by the listener’s goals and/or values aligning with the primed behaviour (Bargh, 2016). There are also mediating effects from the situation, such as a cost-benefit analysis when extending prosocial behaviour to another individual.

An individual’s willingness to engage in prosocial behaviour tends to be higher when that behaviour is directed towards others they perceive as belonging to an “ingroup.” An ingroup is a group of people who bond over shared similarities. Due to a feeling of kinship that is fostered by binary us-vs-them mentalities that often come with belonging to an ingroup, as well as the belief that an individual can understand and is understood by their ingroup members because of the similarities that they share, individuals are more likely to bond and thus engage in prosocial behaviour with those who they share an ingroup with.

However, prosocial behaviour is not only reserved for ingroup members. Individuals are more likely to extend prosocial behaviour towards people they like in order to develop interpersonal relationships. Prosociality encourages social acceptance and assimilation, has a bidirectional relationship with the earliest form of learning: mimicry (van Baaren et al., 2004). Often times, prosocial behaviour emerges due to an individual’s current mood or attitude, independently of any relation to the other party within an interaction. Martins et al., (2022) found that increasing oxytocin levels increased prosocial behaviour between individuals, suggesting a close link between prosociality and mood at the physiological level.

A Note on Previous Literature

Speech perception in itself is an internal process, invisible to a talker during an interaction. As a result, speech perception adaptation does not have the same ability to communicate social cues to others, in contrast to mimicking other’s words, speech patterns, and body language. However, it still holds a critical role in interpersonal communication because it’s what allows individuals to be receptive to a talker they encounter. From the listener’s perspective, it could be advantageous for them to adapt their speech perception more quickly to talker’s that are perceived as more helpful so they can communicate with those individuals more easily.

There is evidence that who an individual hears speech from influences the way they respond (MacFarlane, 2014), and recent research has even found that individuals process information differently when they recognize the speech as coming from an ingroup member (Iacozza et al., 2020). Additionally, listeners can direct their attention to tune into one talker’s speech in a sea of voices, also known as the cocktail party effect (Bee & Micheyl, 2008). The unattended speech may be subconscious processed but is not encoded at the same level as the targeted talker’s speech (Evans et al., 2016).

There is previous literature that suggests that listeners *do not* adapt their speech perception more readily to speech that they like hearing. For example, in Babel et al. (2019), listeners heard one of three distinct voices read a story. One voice produced the standard native English pronunciation, one voice expressed speech with a manipulated accent, and last had the same accent in addition to an atypical change in vowel production. While listeners reported preferring the former two to the latter when hearing the story, listeners’ perceptions adjusted to all of the presented talkers.

While Babel et al., (2019) may support that unpreferred speech does not inhibit speech perception adaptation, there are several factors that should be accounted for: 1) that the preference for a voice was embedded in the acoustic cue itself, 2) the unpreferred speech was an atypical production, and 3) Introducing atypical vowel production may have simulated an outgroup, which could also explain the differences in performance between the shifted condition and the unpreferred condition.

The Design Conundrum

The goal of this experiment would be to test if prosocial cues effect listeners’ speech perception adaptation.

Design A

**Exp. 1:** A between-subject design comparing adaption to an accented talker when there are prosocial cues vs. neutral cues. *Implies that prosocial cues have an effect on speech perception adaptation.*

**Exp. 2:** A follow-up within-subject design comparing adaptation when prosocial cues are associated with one talker when exposed to two. *Distinguishes the effect of prosocial cues effecting speech perception adaptation by A) the listener associating prosociality with a specific talker and changing the way they adapt or B) the listener being in a prosocial mindset themselves changing how they adapt to any novel talker they encounter.*

Problem: If listeners maximally adjust their speech perception to all novel talkers, then we may not see an effect in Experiment 1 (or be able to distinguish effects if prosocial priming is *not* talker specific.

Design B

**Exp. 1:** A within-subject design comparing adaptation when prosocial cues are associated with one talker when exposed to simulated talkers. Use D-T and compare the adaptation. *D-T should* *effect each other; can see which effects more?*

Problem: Listeners tend to have biases in recognizing ambiguous D-T production.

Design C

**Exp. 1:** A between-subject design comparing the rate of adaption to an accented talker when the talker’s accent changes mid-experiment when prosocial cues are introduced (vs. neutral cues.) *Implies that prosocial cues have an effect on speech perception adaptation.*

**Exp. 2:** A follow-up within-subject design comparing adaptation when prosocial cues are associated with one talker when exposed to two simulated talkers. Use S-Sh to be talker specific? *Distinguishes the effect of prosocial cues effecting speech perception adaptation by A) the listener associating prosociality with a specific talker and changing the way they adapt or B) the listener being in a prosocial mindset themselves changing how they adapt to any novel talker they encounter.*

Problem: Introduces a variety of complications in terms of analyzing adaptation across two accents (initial input from a novel talker is susceptible to more flexible learning; see Saltzman & Myers, 2021)

Design D

**Exp.1:** A within-subject design comparing which voice a participant adapts to when they hear two voices simultaneously.

Problem: more about directing attention/attentional preferences?

Design A[[1]](#footnote-1)

The goal of this study is to explore if the effects of prosocial priming extend to speech adaptation. To achieve this, we will run 2 experiments.

**In Experiment 1**, participants will be split into two conditions. One condition will hear a simulated accent paired with prosocial primes. The second condition will hear the same accent paired with neutral cues. The rate of adaptation will be compared between conditions to determine if prosocial cues effect speech perception adaptation.

**In Experiment 2**, each participant will be exposed to two distinct talkers, each with their own novel accent. One talker’s speech will be paired with prosocial cues, while the second talker’s speech is paired with neutral speech. If the adaptation to the talkers differs within subjects, then prosocial cues have a local effect on listener receptiveness to novel speech: the listener perceives that talker as more prosocial, facilitating adaptation to that talker. If there is no difference in listener adaptation between talkers, then prosocial cues have a global effect on listener receptiveness to novel speech: the listener is primed to a more prosocial state, facilitating adaptation to all novel talkers they encounter.

Experiment 1:

The listener population will be divided into two conditions at random. Half the participants will be exposed to Condition 1, which includes a prosocial prime. The other half will be exposed to Condition 2, which includes neutral primes instead.

|  |  |
| --- | --- |
| Conditions | |
| Condition 1 | Condition 2 |
| Prosocial Prime | Neutral Prime |

Table : The two possible conditions for Experiment 1.

The primes will take the form of prosocial and neutral words. These words will be presented both verbally and orthographically, matched with the appropriate accent. Listeners will encounter primes as a response choice on labeled trials, and during catch trials as both the audio and the correct response choice. Utilizing these trials which typically incorporate words unrelated to the experiment will allow us to efficiently implement the primes without substantially changing earlier paradigms.

A picture containing shape

Description automatically generatedA picture containing shape

Description automatically generatedProsocial Prime vs Neutral Prime

Figure 1b: Neutral prime response choice example

Sip

Shade

Share

Sip

Figure 1a: Prosocial prime response choice example

The rate of speech perception adaptation will be compared across conditions. If there is a significant a difference between conditions, **then the presence of prosocial primes effect speech perception adaptation.**

Experiment 2:

Each participant will be exposed to two distinct talkers, each with their own novel accent. An accent here will be defined as having the same shifted /s/-/sh/ distributions, where the ambiguous tokens will be labeled either /s/ (Accent s) or /sh/ (Accent sh). /s/-/sh/ stimuli will be used to simulate the accents because adaptation to this continuum is known to be talker-specific (Cummings & Theodore, *in press.)*

The accents will be paired with either a Prosocial Prime (PP), presented as a word with a prosocial connotation, or a Neutral Prime (NP), presented as a word with a neutral connotation. Primes will be consistently assigned to the same accent throughout the experiment for each participant. This will create 4 possible combinations and a total of two potential conditions:

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Accent | |
| Accent s | Accent sh |
| Prime | PP | Accent s + PP | Accent sh + PP |
| NP | Accent s + NP | Accent sh + NP |

|  |  |
| --- | --- |
|  | Condition A |
|  | Condition B |

Table 2: Possible accent/prime combinations. Neither the accent nor the prime may repeat within a version of the experiment, resulting in the two potential combinations that create conditions A and B, shown in green and blue respectively.

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Condition | |
| A | B |
| Voice | M, F | Accent s + PP + M; Accent sh + NP + F | Accent s + NP + M; Accent sh + PP + F |
| F, M | Accent s + PP + F; Accent sh + NP + M | Accent s + NP + F; Accent sh + PP+ M |

To further the distinctive quality of the voices, one voice will be female (Voice F) while the other will be male (Voice M). To create the male voice, the audio stimuli will be manipulated using Praat (using a formant shift ratio of 1.2 and a new pitch median of 220 Hz). By doing so, we can limit other acoustic cues beyond this manipulation from becoming confounding variables. Previous research does suggest that making these changes to the stimuli will cause listeners to regard the audio as voices from separate talker’s (Cummings & Theodore, *in press;* Tride & Brown-Schmidt, 2012), allowing us to track talker-specific speech perception adaptation when the voices are played across interleaved trials.

|  |  |
| --- | --- |
|  | Condition A |
|  | Condition B |

Table 3: Participants will be split within each condition. Half will experience the Accent + Prime in a male (M, blue) voice and the counterpart in a female (F, red) voice. The other half will be exposed to the opposite.

Presenting the two talkers simultaneously across trials (oppose to blocking the trials based on the talker) will allow us to compare talker-specific perceptual adaptations without there being a biasing effect from whichever accent is presented first. Which voice gender speaks with which accent should be counterbalanced across participants to accommodate potential gender biases (See *Table 3*, above).

This design would allow us to investigate sociability as a moderator for speech perception adaptation, removing potential effects from ingroup biases, such as similarity in prior experiences that would lead to beliefs about that talker potentially matching well with the novel talker’s production. Additionally, we will be able to run within-subject analyses comparing the two voices without confounding effects from the participants desire to participate in the task, as well as the participant’s social network size and prior experiences.

If there is a significant difference between the adaptation of the talker-specific model when comparing the accent/voice paired with the prosocial prime and the accent/voice paired with the neutral prime, **then this would suggest that associating the prime with a talker changes the listener’s receptiveness towards that specific talker.**

Self-Report Measures

Text

Description automatically generatedFurthermore, I propose we include several self-report surveys at the end of the experiment. Including the Prosocial Behavioral Intentions Scale (PBIS) (Baumsteiger & Siegel, 2018) could serve as a gauge of participant’s receptiveness to the prosocial primes presented throughout the experiment. This survey consists of 4 items that require participant responses in the form of 7-point Likert scales:

Figure 2 PBIS instructions and questions. Copied from Appendix in Baumsteiger & Siegel, 2018.

I also think we could include the [Interpersonal Reactivity Index](https://docs.google.com/document/d/1YCKkyg-OVpT0Qz36qFdHM7yeSGj0DsUYgyyx9u7ubnc/edit) (IRI) (Davis, 1980), which may be useful in secondary analyses because it is designed to measure empathy, faceted into 4 distinct dimensions. This self-report includes 28 items rated on 5-point Likert scales, but scoring is admittedly more complex.

For similar reasons, I am also interested in adding the BIS/BAS measures from Carver and White, (1994). The Behavioural Inhibition System (BIS) and the Behavioural Activation System (BAS) were the basis of Gray’s dimensions of personality (Gray, 1981), which was a modification of Eysenck’s dimensions of personality (Eysenck, 1967). Gray’s dimensions of personality are categorized by anxiety proneness and impulsivity, which may correlate to the modern-day measures of emotional reactivity and mood inertia. Both factors would also likely play a role on social acceptance and the development of interpersonal relationships.

~ \* ~

Design D

The goal of this study is to explore if the effects of prosocial priming extend to speech adaptation. To achieve this, we will implement a set of two experiments. **Experiment 1** will determine if the cocktail party effect effects lexically guided perceptual learning when a listener is asked to attend to one of two talker’s speaking simultaneously. **Experiment 2** will then introduce each listener to a simulated prosocial talker and a simulated neutral talker simultaneously. Listener’s speech perceptual adaptation will be compared across the talkers to determine if prosocial primes influence speech perception adaptation, and if these effects are talker specific.

Experiment 1

Each participant will be exposed to two distinct talkers who produce their own novel accent. An accent here will be defined as having the same shifted /s/-/ʃ/ distributions, where the ambiguous tokens will be labeled either /s/ (Accent s) or /ʃ/ (Accent ʃ). Alveolar (s) vs. post-alveolar (ʃ) fricatives will be used because their production is recognized as talker-specific by listeners (Cummings & Theodore, *in press*).

To further the distinctive quality of the voices, one voice will be female (Voice F) while the other will be male (Voice M). To create the male voice, the audio stimuli will be manipulated using Praat (using a formant shift ratio of 1.2 and a new pitch median of 220 Hz). By doing so, we can limit other acoustic cues beyond this manipulation from becoming confounding variables. Previous research does suggest that making these changes to the stimuli will cause listeners to regard the audio as voices from separate talker’s (Cummings & Theodore, *in press;* Tride & Brown-Schmidt, 2012), allowing us to track talker-specific speech perception adaptation using test trials presented in either talker’s voice.

Though it is not anticipated that the simulated talker gender will influence speech perception adaptation, the accent assignment will be counterbalanced across genders to control for any unintended effects. Accents will be consistently assigned to the same gender within a listener’s exposure. This will create four possible talkers, and a total of two potential conditions for this experiment, as shown in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Accent | |
| Accent s | Accent ʃ |
| Gender | M | Accent s + M | Accent ʃ + M |
| F | Accent s + F | Accent ʃ + F |

|  |  |
| --- | --- |
|  | Condition A |
|  | Condition B |

Table Possible gender/accent combinations. Each combination of an accent and a gender represents a possible talker. Neither the gender nor the accent may repeat within a version of the experiment, resulting in the two potential combinations that create Conditions A and B, shown in green and blue, respectively.

Listener’s will be asked to attend to either the male-sounding voice or the female-sounding voice. This also should be counterbalanced within conditions:

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Condition | |
| A | B |
| Attend To | M | Accent s + M; Accent ʃ + F | Accent s + F; Accent ʃ + M |
| F | Accent s + M; Accent ʃ + F | Accent s + F; Accent ʃ + M |

|  |  |
| --- | --- |
|  | Condition A |
|  | Condition B |

Table Participants will be split within each condition. Half will be asked to attend to the male-sounding voice (top) while the other half will be asked to attend to the female-sounding voice (bottom), as noted by underlining.

In each exposure trial, listeners will hear one of the simulated talkers produce a range of fricatives. To simulate the accent, the talker’s ambiguous fricatives will be labeled as either /s/ or / ʃ/ by the offered orthographic response choices. During test trials, listeners will hear both talkers produce a word that begins with a fricative simultaneously. In theory, this will force the listener to choose one of the two talkers to attend to, similar to speech processing in the cocktail party effect (Bee & Micheyl, 2008). Listeners will be instructed which voice they should attend to at the beginning of the experiment. Participants will then select either a response choice beginning with “s” (e.g., sign) or “sh” (e.g., shine). At the end of the experiment, listeners perception of each talker’s range of fricative production will be tested using unlabeled trials where the trials are presented in each talker’s voice. If there is a significant difference in adaptation between the two talkers, then we can conclude that **attending to one talker when multiple speakers are talking inhibits speech perception adaptation to the speakers the listener is not attending to.**

Experiment 2

Experiment 2 will follow a similar structure to Experiment 1, with the exception that prosocial primes will be integrated into one of the presented voices. Within the experiment, each talker will be paired with either a Prosocial Prime (PP), presented as a word with a prosocial connotation, or a Neutral Prime (NP), presented as a word with a neutral connotation. Primes will be consistently assigned to the same talker throughout the experiment for each participant. This will create 4 possible combinations and a total of two potential conditions:

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Accent | |
| Accent s | Accent ʃ |
| Prime | PP | Accent s + PP | Accent ʃ + PP |
| NP | Accent s + PP | Accent ʃ + NP |

|  |  |
| --- | --- |
|  | Condition A |
|  | Condition B |

Table 3 Possible accent/prime combinations. Neither the accent nor the prime may repeat within a version of the experiment, resulting in the two potential combinations that create conditions A and B, shown in green and blue respectively.

The prime will be presented both verbally and orthographically, matched with the appropriate accent. Listeners will encounter primes as a response choice on labeled trials, and during catch trials as both the audio and the correct response choice. Utilizing these trials which typically incorporate words unrelated to the experiment will allow us to efficiently implement the primes without substantially changing earlier paradigms.

A picture containing shape

Description automatically generatedA picture containing shape

Description automatically generatedProsocial Prime vs Neutral Prime

Figure 1b: Neutral prime response choice example

Sip

Shade

Sip

Figure 1a: Prosocial prime response choice example

Share

The talkers will also be presented as two different genders, like in Experiment 1, to further listener’s distinction between the two voices. As a result, gender should again be counterbalanced between conditions though we do not anticipate any differences in speech perception adaptation.

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Condition | |
| A | B |
| Prosocial Prime | M | Accent s + M; Accent ʃ + F | Accent s + F; Accent ʃ + M |
| F | Accent s + M; Accent ʃ + F | Accent s + F; Accent ʃ + M |

|  |  |
| --- | --- |
|  | Condition A |
|  | Condition B |

Table 4 Participants will be split within each condition. Half will experience the Accent + Prime in a male (M, blue) voice and the counterpart in a female (F, red) voice. The other half will be exposed to the inverse.

In each exposure trial, listeners will hear one of the simulated talkers produce a range of fricatives. To simulate the accent, the talker’s ambiguous fricatives will be labeled as either /s/ or / ʃ/ by the offered orthographic response choices. The labeled trials will include either the prosocial or neutral prime. During test trials, listeners will hear both talkers produce a word that begins with a fricative simultaneously. This will again hopefully result in the cocktail party effect, which ideally will have been proven to inhibit speech perception adaptation to the unattended talkers in Experiment 1.

This would then allow us to test the effect of prosocial primes on talker-specific speech perception adaptation, and would also allow us examine general effects by comparing the results of this experiment to those of Experiment 1.

Unlike in experiment 1, listeners will *not* be instructed to attend to a specific talker. Participants will then select either a response choice beginning with “s” (e.g., sign) or “sh” (e.g., shine). At the end of the experiment, listeners perception of each talker’s range of fricative production will be tested using unlabeled trials where the trials are presented in each talker’s voice. If there is a significant difference in adaptation between the two talkers, **then these results may imply that prosocial primes have a talker-specific effect on a listener’s speech perception adaptation.** If there is a significant difference between the results of Experiment 1 and Experiment 2, **then these results may imply that prosocial primes have a general effect on a listener’s speech perception adaptation.**

Self-Report Measures [[2]](#footnote-2)

Text

Description automatically generatedFurthermore, I propose we include several self-report surveys at the end of the experiment. Including the Prosocial Behavioral Intentions Scale (PBIS) (Baumsteiger & Siegel, 2018) could serve as a gauge of participant’s receptiveness to the prosocial primes presented throughout the experiment. This survey consists of 4 items that require participant responses in the form of 7-point Likert scales:

Figure 2 PBIS instructions and questions. Copied from Appendix in Baumsteiger & Siegel, 2018.

I also think we could include the [Interpersonal Reactivity Index](https://docs.google.com/document/d/1YCKkyg-OVpT0Qz36qFdHM7yeSGj0DsUYgyyx9u7ubnc/edit) (IRI) (Davis, 1980), which may be useful in secondary analyses because it is designed to measure empathy, faceted into 4 distinct dimensions. This self-report includes 28 items rated on 5-point Likert scales, but scoring is admittedly more complex.

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Questions moving forward:

***Priority:***

* **Design -**feedback? Thoughts? Comments? Criticism?
  + Thoughts on Design D and the cocktail party effect?

***Other:***

* What prosocial words should be used as primes?
  + What types of neutral words would balance these out well?
* When should test trials be added throughout the talker exposure?
  + Interspersed in addition to at the beginning + end?
* Which scales should be included? Should any scales be excluded?
  + Other measures/ideas?
* Exclusion criteria
  + Similar to what we have implemented in past experiences
  + Changes based on Cummings & Theodore (*in press*).

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1. Design A has some flaws, noted on the Design Conundrum page. However, it is likely that this design will be the basis for later iterations. [↑](#footnote-ref-1)
2. No changes from Design A [↑](#footnote-ref-2)